EDITION /005

EDUSCAPES

AN SUTD PEDAGOGY MAGAZINE

SINGAPORE UNIVERSITY OF TECHNOLOGY AND DESIGN

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AIMS

This magazine aims to promote and celebrate teaching excellence and experience at SUTD, by taking a reflective, evidence-based empirical approach into teaching and learning practices at SUTD and beyond, to identify innovative and effective pedagogies for SUTD. We also hope that the magazine will serve as a platform for sharing pedagogical resources on technology and library tools.

MANAGING OFFICE

As a central and university lab on teaching and learning, Learning Sciences Lab (LSL) from the Office of Undergraduate Studies (UGS) plays a vital role in shaping and coordinating this magazine, by leading and working with various stakeholders from SUTD.

LSL, established at SUTD in July 2016, aims to support instructors and learners in engaged teaching and learning. LSL offers various programs and services on teaching and learning to faculty members, graduate teaching assistants and learners. LSL aims to build communities of practices in teaching and learning at SUTD - within and in collaboration with other universities and industrial partners. LSL is led by Dr. Nachamma Sockalingam, with the support of Mr. Clement Lim.

GUIDELINES FOR SUBMISSION

We accept a variety of articles in the form of:

Current Issues

This could be a write-up of the latest happenings in the education industry on topics such as Learning Analytics or Extended Reality etc.

Reflections

This would be opinion and reflective pieces that involve sharing of perspectives and experiences

Research Articles

Research articles are empirical, evidence-based write-ups of action research/inquiry into teaching and learning

Different Perspectives

This would be interviews with various stakeholders or opinion pieces

Book Reviews

Review of books on pedagogical topics

Teaching Resources

Write-ups from various offices in SUTD/external stakeholders on teaching resources

Your article should

- Meet the aims and scope of the newsletter
- Be well-written and easy to follow, without unnecessary technical jargons
- Be original – not reprinted anywhere else unless copyright cleared
- Go beyond being descriptive – should attempt to take a more empirical, reflective approach
- Highlight the impact and significance of the findings

Please contact the editorial board or Nachamma@sutd.edu.sg if you are keen to submit articles for the next issue.

Editor's Notes

It is our great pleasure to bring you the fifth edition of our SUTD pedagogy magazine: EduSCAPES. It presents the diverse educational landscapes at SUTD in one place, providing a refreshing escapade from the humdrum and daily routines of academic life, especially in the stressful pandemic situation.

EduSCAPES brings research articles, reflections, opinion pieces, information and announcements from diverse members of the SUTD colleagues, in their own voices. We hope to include articles from the community rather than writing on behalf for the community.

This is a magazine for the community by the community. We thank all who have contributed to this edition. While this magazine is meant primarily for the SUTD stakeholders, we also know that other educational institutions, and even potential students and parents could benefit from this magazine as it serves as a magnifying lens into SUTD's educational efforts.

Year on year, we are receiving more article submissions, and participation from new members. It is a great pleasure to note that this year we have contributions from all the pillars and clusters at SUTD, and this includes faculty members, staff members, graduate students and even potential SUTD students.

The magazine consists of a total of 11 articles. The reflections are grouped as articles on cyber physical learning and on design education. Both the set of reflections include elements of design and cyber-physical education. However, we wanted to make the distinction ¬¬since the reflections on design education are the top three submissions for the Design Education Summit 2020. Congratulations to the authors of these top three submissions. LSL is delighted to partner with Design Education Summit 2020 organizers in publishing these design education practices.

We are also seeing more achievements, especially in the form of publications of journal papers, and conference proceedings/conference linked papers. In addition, we are seeing diverse forms of achievements in teaching - whether it is at national or international- levels. We are happy for our colleagues' achievements and congratulate them. We share these stories to inspire and promote such initiatives amongst others.

Overall, it is really encouraging to see the growth of participation and achievements in educational Scholarship of Teaching and Learning (SOTL) and professional development in teaching; which goes to showcase the efforts towards providing quality education for our learners.

At the end of the day, SOTL and faculty development work at SUTD focuses on the learners, their learning, and how we can support the learners in their learning process.

It is also heartwarming that the SUTD Pedagogy Magazine inspires the pillars and clusters to also kick-start their own pedagogical groups, events and even newsletters. For instance, Science, Mathematics and Technology Cluster have their own research cum pedagogy newsletter and there are several pedagogical interest groups. We see this as a healthy sign of growth and development; and we encourage the different pedagogical initiatives to always continue to connect back with Learning Sciences Lab so that the pillar/cluster level participations can be cross-cultivated and nurtured at the university-level. There is strength in unity.

The theme for this year's EduSCAPES magazine is "Learning in the Ever Changing Norm" in addressing the unprecedented and unexpected situation of COVID-19 that we continue to face. The pandemic situation seems to be becoming the new norm, and we may not know if this is going to stabilize or remain volatile. The outlook is rather unpredictable.

Managing and doing well in stable conditions is far easier and straightforward than in Volatile, Uncertain, Complex and Ambiguous (VUCA) situations such as what we are experiencing at present.

The way forward then seems to be to that we have to be more creative and yet systematic in our approach, be adaptable, flexible and be informed by the best data that is possibly available or derivable in these complex and ambiguous times. The other important aspect would be to reflect on the steps taken and analyze. This form the fundamentals of circular education mentioned by our Provost Professor Phoon Kok Kwang in his interview article in this magazine. It is important to be well-informed, evidence-based and reflective as a learner.

While we work towards preparing our students for the VUCA world as mentioned in our provost's interview, we as teachers will also have to continue to self-develop to teach in the VUCA world. How can we achieve this?

Scholarship of Teaching and Learning (SOTL) takes a similar approach as circular education, albeit, for learning how to teach. SOTL as a professional development tool emphasizes public sharing of the knowledge gained. One of the main objectives of this pedagogy magazine, EduSCAPES, is to nurture and promote the public sharing of pedagogical knowledge at SUTD.

Again, the solution could be in the mantra of "strength in unity". Expert individuals can go far; but many individual experts coming together can go even further. Thus, sharing and working together is very essential for progress. That is what this magazine aims to achieve and works toward.
Our SUTD colleagues demonstrate the collegiality and cooperativeness in this magazine in many ways. There are many pedagogical projects that have been funded by the Office of Undergraduate Studies (over the years) and it can be seen that these projects have multiple leads, co - investigators and partners. Similarly, assembling the various articles has involved different individuals and groups- from faculty teams to editorial board members.
Teaching, like learning, is no longer just about an individual's (teaching) activity or expertise in a particular field.

This is especially pronounced in cyber-physical learning. Cyber-physical teaching and learning is not just merely digitizing learning materials to be online. It is transforming or redefining the learning experiences using technology in teaching and learning. This is no easy task since technology tools may not be fitting to the needs of the students and teachers, or certain aspect of learning is difficult to be addressed by the existing technology tools. But there can also be some existing tools that allow us to engage students effectively.

So, a primary question for our faculty members at SUTD is "How can we transform our SUTD's signature pedagogy of multi/inter disciplinary teaching and learning using design centric projects to be taught in a blended, cyber-physical format, whether using existing tools or by innovating technology tools.

The reflections from our SUTD community on cyber-physical and design education shared in this edition attempts to shed some light on this.
These reflections range from focusing on particular aspects of teaching and learning such as assessment or using e-rubrics for assessment to considering blended learning as a whole concept. Holistically, teaching involves various aspects such as curriculum development, instructional design, teaching, guiding, project management, assessment and feedback in engaging and empowering the learners.

Going cyber-physical may involve taking step-by-step approach in some cases and it may be taking a holistic approach in other cases. This is context based. For instance, if the curriculum team has very short time frame for changes, the team may decide to focus on one particular aspect of teaching such as creating videos for lectures. Or the team may want to focus on one aspect such as assessment over a period time longitudinally, so as to develop a more sustainable digital tool (e.g., Use of Cerebry for assessment and personalized learning of mathematics mentioned in this magazine). So the choice and extent of going cyber-physical depends on many factors. It involves committed time over a period, even when we are agile.

We encourage our readers and teachers to refer to the various articles in this edition of EduSCAPES magazine and consider the diverse types/formats of cyber physical learning as well as design education and the educational contexts. No one size fits all. We also encourage them to refer to the earlier editions to see the progress of developments of projects over the time and draw inspirations and ideas from these various examples. LSL also aims to connect various stakeholders of the SUTD family through the magazine and work with them on these projects.

Our goal as a SUTD community would be to take the necessary steps in redefining teaching and work towards agile transformations where possible, and progressively build it up, one step at a time, as a community. A thousand-mile journey starts with the first step and it takes the whole village to raise a child. We at LSL will be happy to work with you in discussing your ideas, collaborating and connecting on pedagogical projects.

Given that SUTD's pedagogy model is possibly special in many ways (Such as team teaching, design-centric project-based learning, Big D framework etc.), one of our realizations at SUTD is that many of the existing educational technologies can be limited, especially in aspects of social connectivity in teaching and learning. This element is rather important for SUTD. Hence, it is essential that SUTD works with industrial partners and edtech companies to possibly develop new

learning technologies for SUTD's pedagogy. So that is perhaps what our SUTD faculty members can work towards as the next step. This is where the twin aspect of the SUTD magazine: the SUTD Pedagogy Day comes in.

The SUTD Pedagogy Magazine is released annually on the SUTD Pedagogy Day. While the SUTD magazine documents the past achievements, and findings from the last one year, the SUTD Pedagogy Day aims to project what we can possibly achieve in the future based on the current practices.

The way forward certainly seems to be in cyber-physical learning, also referred to as campusX at SUTD, and that is what we have tried to cover in 2021's magazine and pedagogy day. This year's EduSCAPE magazine cover attempts to visualize what a futuristic learning may look like at SUTD; learning using a combination of physical and online learning, combined with extended reality in multi-modes; whether face-to-face, or in virtual mode, or in a mixed cyber physical mode. For example, while 5 members of a student team may be in campus, one member could be virtually located and yet collaborating through the internet on a practical, design project using extended reality.
Painting a picture of a positive future will give us a north star and encourage us to work towards the vision during the tough days along the way. And that is what this visualization is about.

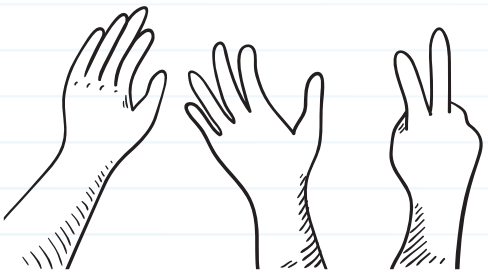
The creativity of our faculty, staff members and students in adapting to and transforming their pedagogical practices to enable active and interactive teaching, as evidenced in this magazine, gives hope that we will certainly ride out this pandemic and that we will be able to even innovate and develop better approaches and tools in teaching and learning.

We certainly hope that you find the magazine informative, enjoyable and inspiring. We thank everyone involved in making this magazine a possibility.

This is an annual magazine and we invite all interested in SUTD's pedagogy (including and especially students) to contribute to subsequent issues. Please see the guidelines for submission. We look forward to your contributions. Share with us and others your insights, reflections, findings on teaching and learning by emailing us at nachamma@sutd.edu.sg.


ACHIEVEMENTS

PEDAGOGICAL GRANTS/FUNDS NATIONAL LEVEL



External and competitive educational research funds from national organizations such as the Ministry of Education and National Institute of Education are available on an annual basis. For more information on such research funds, please contact Ms. Ketut Nita Santoso from the Office of Research at ketut_santoso@sutd.edu.sg. LSL provides collaboration and consultation services on educational projects.

A. MINISTRY OF EDUCATION- TERTIARY RESEARCH FUND 2020

PROGRAMMATIC CATEGORY

Research Title: Artificial Intelligence for Assessment in Design Education (AIDE)

Lead Principal Investigator
Professor Lucienne Blessing (EPD)

Co-Principal Investigator
Assistant Professor Lim Kwan Hui (ISTD)

Co- Investigators
Dr. Nachamma Sockalingam (LSL)
Ms. Rachna Johri (Temasek Polytechnic)
Ms. Tan Mui Siang (Nanyang Polytechnic)

Collaborators
Mr. Albert Lim (Nanyang Polytechnic)
Assistant Professor Carlos Bannon (ASD)
Dr. Franklin Anariba (SMT / EPD)
Assistant Professor Michael Budig (ASD)
Associate Professor Ngai-Man Cheung (ISTD)
Assistant Professor Pablo Valdivia (EPD)
Professor Peter Jackson (ESD)
Assistant Professor Sudipta Chattopadhyay (ISTD)
Assistant Professor Ryan Arlitt (Technical University of Denmark)

Acknowledgements

Main contributor: Dr. Sumbul Khan

About the research

One of the biggest challenges in design education is the fair and thorough assessment of students' design skills. The complexity and ill-structured nature of design problems does not lend itself easily to measurable outcomes. This research addresses the issue of assessment in Design Education with the overall aim to conceptualize, develop and evaluate Artificial Intelligence (AI) based methods and platforms for assessing the acquisition of design competencies at the tertiary education level in Singapore. A specific aim of the research program is to develop assessment measures and platform for design competencies as specified in the Skills Framework for Design (SFD), developed by Skillsfuture, Singapore. The program involves design courses and their lead instructors from Singapore University of Technology and Design, and from Schools of Design at Temasek Polytechnic and Nanyang Polytechnic.

B. NIE EDUCATION RESEARCH FUNDING PROGRAMME (ERFP)

INDIVIDUAL CATEGORY

Research Title: Exploring Extended Reality to Enhance Practical Science and Mathematics Education

Principal Investigator
Assistant Professor
Cheong Kang Hao
Science, Mathematics
and Technology (SMT)

Co-Principal Investigator
Assistant Professor Leo Chen Huei
Science, Mathematics and
Technology (SMT)

About the research

With the current COVID-19 pandemic, science laboratory sessions are effectively on a standstill whether it is in school, where social distancing is practiced, or during home-based learning at home. When approached by some Ministry of Education (MOE) secondary schools, and supported by NIE, the team decided to explore the usage of augmented (AR) and virtual reality (VR), collectively called extended Reality (XR), to enhance teaching and learning for off-site science practical and mathematics lessons.

C. SUTD PEDAGOGY LEADERSHIP GRANT 2021

The Pedagogy Leadership Grant (PLG) is administered by the Office of Undergraduate Studies (UGS) and funded by the SUTD Growth Plan (SGP). PLG was first launched in May 2020. This initiative is set up to fund pedagogy research and innovation initiatives within SUTD. Through the PLG, SUTD stimulates faculty member's interests in developing and enhancing pedagogical applications to promote effective and innovative practices which can potentially improve the quality of SUTD's unique pedagogy across all pillars and clusters.

PLG projects come in one of the categories below:

- Thematic Projects are projects motivated by a central research question and championed by a Lead PI. These projects should address issues which cut across pillars and clusters in SUTD (e.g. Big-D, cohort-based learning, student assessment and evaluation). Proposals based within an individual pillar or cluster are also welcome.
- Pedagogy Advancement Projects are single projects led by a Principal Investigator (PI).

All SUTD faculty and adjunct faculty members can apply for funding. The call of proposal is typically done once annually in the Spring term. For more information on applying for the Pedagogy Leadership Grant, kindly contact Dr Ong Eng Hong at enghong_ong@sutd.edu.sg. You can contact LSL to provide collaboration and consultation services on educational projects.

Thematic Project 2021

From BigD to BigD+: An SUTD Community-led Development of Next-Gen Design Education

Principal Investigator
Professor Lucienne Blessing (EPD)

Co-Principal Investigators
Dr. Edwin Koh (DAI / EPD)
Dr. Franklin Anariba (SMT / EPD)
Assistant Professor Immanuel Koh (ASD)
Dr. Kwan Wei Lek (SMT / DAI / EPD)
Dr. Kenny Choo (DAI / ISTD)
Dr. Nachamma Sockalingam (LSL, UGS)

Collaborators
Dr. Apple Koh (SMT / EPD)
Associate Professor Bige Tuncer (ASD)
Dr. Chandrima Chatterjee (SMT)
Associate Professor Jeffrey Chan Kok Hui (DAI / HASS)
Associate Professor Joel Yang (EPD)
Dr. Khoo Xiaojuan (SMT / EPD)
Dr. Lee Chee Huei (SMT / EPD)
Associate Professor Low Hong Yee (EPD)
Dr. Maggie Pee (SMT)
Dr. Natalie Agus (ISTD)
Assistant Professor Michael Budig (ASD)
Dr. Oka Kurniawan (DAI / ISTD)
Assistant Professor Pablo Valdivia Y Alvarado (EPD)
Professor Peter Jackson (ESD)
Associate Professor Stefano Galelli (ESD)
Assistant Professor Subburaj Karupppasamy (EPD)
Dr. Tan Mei Xuan (SMT)

Pedagogy Advancement Project 2021

Towards a Design-Centric Freshmore Physics Classroom Through the Reverse Engineering Pedagogy (REP)

Principal Investigator
Dr. Tan Da Yang (SMT)

Co-Principal Investigators
Associate Professor Arlindo Silva (EPD)
Dr. Cheah Chin Wei (SMT / EPD)
Dr. Ching Chee Leong (SMT)
Associate Professor Dario Poletti (SMT / EPD)
Dr. Kwan Wei Lek (SMT / DAI / EPD)
Dr. Lee Chee Huei (SMT / EPD)
Assistant Professor Liu Xiaogang (SMT)

AI Based Automated Feedback and Grading for Novice Programmers

Principal Investigator
Dr. Oka Kurniawan (DAI / ISTD)

Co-Principal Investigators
Dr. Cyrille Jegourel (ISTD)
Dr. Nachamma Sockalingam(LSL, UGS)

Collaborators
Assistant Professor Chris Poskitt (SMU)
Dr. Norman Lee Tiong Seng (ISTD)

D. SUTD PEDAGOGY INNOVATION GRANT 2021

Pedagogy innovation is one of the key aspects in education. It aims to drive novel teaching techniques and products to enhance learning, ensure that education is kept abreast with the times, maintain and improve the quality of higher learning in institutions.

The SUTD Pedagogy Innovation grant started in 2014 and this initiative allows faculty to carry out ground-up creative projects that innovate the way they teach here at SUTD. Successful pedagogical strategies and applications are demonstrated in SUTD's classes and shared with the faculty community at the annual SUTD Pedagogy Day.

From this, SUTD aims to be at the forefront of educational technology and pedagogy and also set an example for future residential education based on its cohort-based lessons, active and interactive learning products and innovative pedagogies.

The Pedagogy innovation proposal call is held annually and in the Fall term. The call for proposal is open to all SUTD faculty members and successful applicants will receive a maximum of SGD$15,000 funding, for the stipulated duration of the project and is to be spent in accordance with the Pedagogy Funding Guidelines.

For further enquiries on the SUTD Pedagogy Innovation grant, please contact Ms. Siti Aisyah at siti_aisyah@sutd.edu.sg or Mr. Toe Oo Zaw at oozaw_toe@sutd.edu.sg. You can contact LSL to provide collaboration and consultation services on educational projects.

1. Voices on Assessment Methods

Principal Investigator
Dr. Apple Koh (SMT / EPD)
Co-Principal Investigators
Dr. Maggie Pee (SMT)
Dr. Tan Mei Xuan (SMT)

2. Virtual Map for Visualization of Learning Outcomes and Courses' Attributes

Principal Investigator
Dr. Oka Kurniawan (DAI / ISTD)
Co-Principal Investigators
Dr. Norman Lee Tiong Seng (ISTD)
Dr. Natalie Agus (ISTD)
Team members
Mr. Toe Oo Zaw (UGS)
Ms. Tin Ma Ma (UGS)

3. The Future of Learning the Past

Principal Investigator
Dr. Sandeep Ray (HASS)
Co-Principal Investigators
Assistant Professor Liu Jun (ISTD)

4. Enhancement of Students' Understanding of Potential Energy and Conservative Force Concepts by Physics-Math Integration Pedagogy

Principal Investigator
Dr. Wu Chunfeng (SMT / EPD)
Co-Principal Investigator
Dr. Lee Chee Huei (SMT / EPD)

5. Redesign and Evaluation of CHART, A Real-Time Digital Feedback Tool

Principal Investigator
Dr. Khoo Xiaojuan (SMT / EPD)
Co-Principal Investigators
Dr. Andrew Yee (HASS)
Dr. Oka Kurniawan (DAI / ISTD)
Dr. Yajuan Zhu (SMT)

6. Exploring the World of Chemistry Through Virtual Reality

Principal Investigator
Dr. Chandrima Chatterjee (SMT)

7. Course Health - Nurturing and Monitoring Attributes in Students

Principal Investigator
Assistant Professor Michael Budig (ASD)
Co-Principal Investigators
Assistant Professor Mohan Rajesh Elara (EPD)
Ms. Teo Su Chern (SMT)

8. Remote Experiment for Engineering Courses

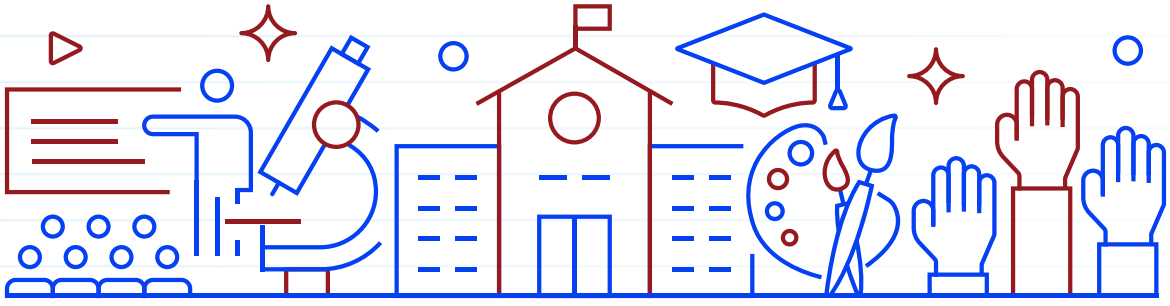
Principal Investigator
Dr. Teo Tee Hui (SMT / EPD)

9. Linear Algebra by Poly a Design

Principal Investigator
Dr. Keegan Kang (ESD)
Co-Principal Investigators
Assistant Professor Liu Xiaogang (SMT)
Dr. Omar Ortiz (ESD)
Dr. Tan Da Yang (SMT)
Assistant Professor Wang Xingyin (ESD)
Dr. Wong Wei Pin (SMT / ESD)
Team Member
Dr.Sergey Kushnarev (ISTD)

10. Teaching Structures to Architects - Think, Experience, Communicate and Design

Principal Investigator
Assistant Professor Sam Conrad Joyce (DAI / ASD)
Co-Principal Investigators
Ms.Yvonne Wong (PhD)



AWARDS AND CERTIFICATIONS

A. INTERNATIONAL FELLOWSHIP IN HIGHER EDUCATION

SUTD emphasises both research and teaching and values the professional development of faculty members in teaching as well as research (President, Professor Chong Tow Chong, EduSCAPES 2018). One of Learning Sciences Labs (LSL) core services is in supporting faculty member's continued professional development in teaching.To this end, LSL has initiated and developed the SUTD-AHE Fellowship programme as a form of leadership training and development in higher education.

The SUTD-AHE programme is conducted in partnership with Advance Higher Education (AHE), from the United Kingdom, to provide an avenue for international professional recognition of teaching in higher learning. This Fellowship involves submission of a reflective portfolio of teaching practices to AHE and it is peer - reviewed by international higher education professionals. LSL provides scaffolding and support in this journey. The reflective journey allows participants to take stock of work they have done, and helps them to plan their professional development in teaching and learning while recognizing their past contributions and achievements. It thus takes into account the past, present and the future.

The programme also aims to document teaching practices at SUTD for pedagogical knowledge management and advancement, to encourage reflective practices for teaching quality assurance and enhancement, and to move beyond individual instructor development to community development in teaching at SUTD (Sockalingam, N., EduSCAPES, 2018, 2019, 2020).

A university-level Faculty Educational Development Community, composed of senior faculty members from each of the Pillars and Clusters were consulted in formulating the policies and practices of the SUTD Educational Fellowship Programme and the various Heads of Pillars/Clusters were involved in nominating the faculty members. The nominations are based on a number of factors such as length of service, past performance and future potential.

This programme was piloted with a first batch of 12 SUTD participants in 2019/2020. Seven faculty members and one staff member had applied and all applicants had obtained their fellowships successfully. More information on this can be found here: https://www.advance-he.ac.uk/news-and-views/first-principal-fellow-singapore-and-success-sutd-educational-fellowship-programme.

The 2021 SUTD-AHE program involves another batch of 12 SUTD faculty members and is facilitated by Principal Fellow Dr. Julie Baldry Currens (AHE) and Principal Fellow Dr. Nachamma Sockalingam (SUTD). The following faculty members have been nominated by their pillar/cluster heads to participate in the 2021 SUTD-AHE Fellowship Programme. We wish them success in their application.

SUTD-AHE PROGRAMME

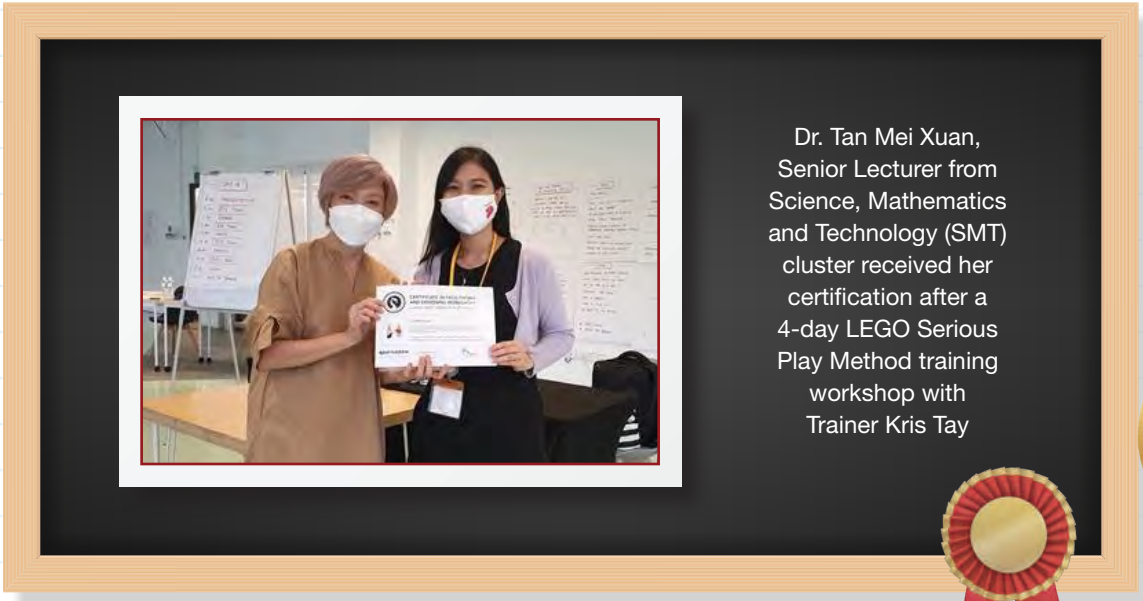
Pillar/ Cluster	Faculty Names
ASD	*Dr. Daniel Joseph Whittaker, Senior Lecturer* *Dr. Jason Lim, Lecturer*
ESD	*Dr. Keegan Kang, Lecturer*
EPD	*Dr. Foong Shaohui, Associate Professor* *Dr. Tan Mei Chee, Associate Professor*
ISTD	*Dr. Kenny Choo, Senior Lecturer* *Dr. Natalie Agus, Lecturer*
HASS	*Dr. Paolo Di Leo, Senior Lecturer*
SMT	*Dr. Apple Koh, Senior Lecturer* *Dr. Chandrima Chatterjee, Senior Lecturer* *Dr. Kwan Wei Lek, Senior Lecturer* *Dr. Tan Mei Xuan, Senior Lecturer*

B. INTERNATIONAL CERTIFICATIONS IN EDUCATION

TEACHING CERTIFICATE IN HIGHER EDUCATION

AHE Fellow and Assistant Professor Nilanjan Raghunath, from HASS received her Higher Education Teaching Certificate from The Derek Bok Center for Teaching and Learning in August 2020.

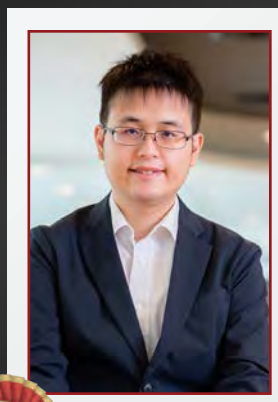
CERTIFICATE TO DESIGN AND FACILITATE WORKSHOPS USING THE LEGO SERIOUS PLAY METHOD, APRIL 2021



Dr. Tan Mei Xuan, Senior Lecturer from Science, Mathematics and Technology (SMT) cluster received her certification after a 4-day LEGO Serious Play Method training workshop with Trainer Kris Tay

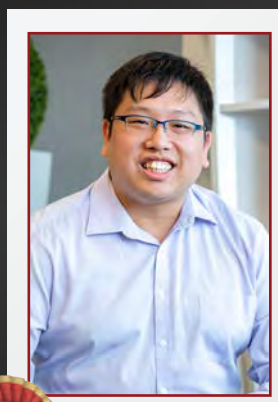
C. MOE-SCIENCE MENTOR PROGRAMME (SMP) OUTSTANDING MENTOR AWARD

Science Mentorship Programme (SMP) is jointly organised by the Gifted Education Branch of the Ministry of Education (MOE) with the local tertiary institutions which includes universities, polytechnics and research institutes. The programme is targeted at secondary 3 and 4 students from School-Based Gifted Education (SBGE) and Integrated Programme (IP) schools, for students who demonstrate a keen interest in and have the aptitude for scientific research. Faculty mentors are invited to offer research projects for the students in November. Students who are keen to participate in the programme could apply for projects that interest them in January of the following year. Successful applicants will work on their projects, and at the end of the programme, they are required to present their research findings during the Youth Science Conference (YSC). SUTD faculty members Dr. Keegan Kang (SMT) and Dr. Tan Da Yang (SMT) have participated and received awards at the event. Both faculty have been awarded the SMP Outstanding Mentor award for 2020. This is Dr. Tan's first award, and Dr. Keegan's second award in their SMP journey.



Dr. Keegan Kang
Lecturer
Engineering Systems and Design (ESD)

Recipient for
- 2020 Outstanding Mentor Award for SMP.
- 2020 Inspiring Mentor Award (by NUS High) for SMP
- 2019 Outstanding Mentor Award for SMP



Dr. Tan Da Yang
Lecturer
Science, Mathematics and Technology (SMT)

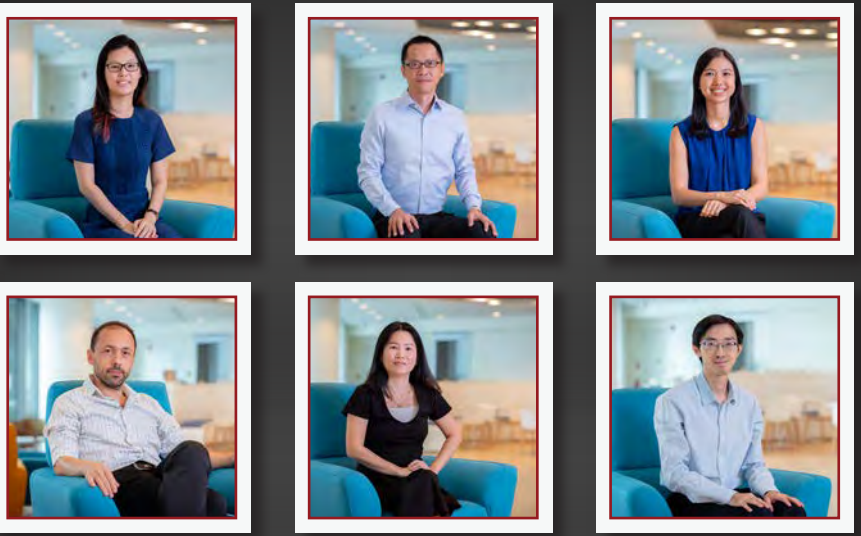
Recipient for
- 2020 Outstanding Mentor Award for SMP

D. SUTD OUTSTANDING EDUCATION AWARD

SUTD Teaching Excellence Award is an annual award that celebrates excellence in teaching and is given by the Office of Human Resources & Organization Development. This year, we celebrate individual and team achievements.

Dr. Khoo Xiaojuan
Senior Lecturer
Science, Mathematics & Technology (SMT)

"There are many things that I am proud to have achieved in my life, but what I find most meaningful, instead of a single achievement, has been the entire journey of getting to where I am today."



From Top Left
Dr. Apple Koh, SMT
Dr. Kwan Wei Lek, SMT
Dr. Tan Mei Xuan, SMT

From Bottom Left
Dr. Massimilliano Colla, SMT
Dr. Maggie Pee, SMT
Dr. Lee Chee Huei, SMT

"Winning the award as a team. This year has been especially difficult for many of us. Knowing that we have each other's back covered is reassuring. The camaraderie was excellent as all of us were trying to ensure that our students continued to have a good learning experience during the circuit breaker."

ACADEMIC PEDAGOGICAL PUBLICATIONS

JOURNAL PAPERS

An Investigation into the Impact of Flipped Classroom with Active Learning on the Perception and Performance of Biology Non-Major Students at the Undergraduate Level

Bina Rai, Julia Yajuan Zhu, Dawn C-I Koh, Khoo Xiaojuan, Lakshminarasimhan Krishnaswamy, Rajesh Chandramohanadas, Ong Eng Shi, and Pey Kin Leong

Journal of College Science Teaching, November/December 2020 (50, 2).

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DIFFERENT
PERSPECTIVES

AN INTERVIEW WITH SUTD'S PROVOST PROFESSOR PHOON KOK KWANG

Professor Phoon Kok Kwang officially joined SUTD in February 2021. He brings to SUTD over 25 years of experience as a world-class researcher, top educator and active senior academic leader. Prof Koh Kwang was also the Task Force chair on Continuing and Professional Education that led to the establishment of NUS' School of Continuing and Lifelong Education in 2015.

Dr. Nachamma Sockalingam from the Learning Sciences Lab catches up with Professor KK as he is fondly known, on his visions and plans for SUTD.

1. Prof KK, what do you see as the role of SUTD education in today's world?

This is an interesting question. One approach is that we can consider our starting and destination points. In our case, we can ask ourselves, "what do we want our SUTD students to achieve during the 4-year learning journey in SUTD so as to prepare them for the future, say 40-50 years after graduation". This is beyond immediate employment.

Of course, there is lifelong and continued learning. So undergraduate education is not a terminal destination. In reality, the demarcation between undergraduate education and lifelong learning is blurred, but drawing a stark contrast will focus our attention on what a student should prioritize in his or her learning journey at SUTD.

So, what should a student focus on in his/her learning journey in SUTD?

I firmly believe that the undergraduate learning journey is a "golden period" with three distinctive features: (1) it offers full-time learning opportunities with minimal distractions (e.g. work, family commitments, etc.), (2) provides a safe and nurturing learning environment to explore and make mistakes, and (3) takes place while students are full of youthful energy, imagination, and aspirations. Also, undergraduate education is vital for instilling good learning habits that are key to lifelong learning. Thus, students should make the best use of their time in SUTD.

Any discussion on the future of education must consider the changing external landscape which at least has three distinctive features: (1) changes are ever present, ongoing, and significant, (2) the future of societal needs and employment is shifting and uncertain, and (3) the pace of change has been accelerated as a result of the pandemic. Jobs that used to exist are no longer in existence or needed, and new jobs/fields of study and work are being created as we speak. In other words, it is a world in transition. Although there is limited clarity on the duration of this transition, we should view this change positively as a second renaissance. In my opinion, SUTD is well positioned to be a new "Florence".

As a result of the ongoing industry transformation and shifting social norms, education is being re-imagined. An example of this is the 2016 World Economic Forum (WEF) Report entitled "New Vision for Education: Fostering Social and Emotional Learning through Technology". This report predicts that jobs of the future will be transformed at a rapid pace in terms of job availability, delivery, and connectivity (how individuals networked within a cyber-physical environment to deliver a product/service), etc.

As such, current ways of producing a product or delivering a service, how people organize themselves in the workplace, and even the nature of the workplace itself will need to adapt and transform to keep up with these changes. The ways we live, work and play are unlikely to remain status quo 5 years from now.

In a discussion on the post-Covid economic outlook on employment and employability in the pandemic world, Mr Chng Kai Fong, past Managing Director of Economic Development Board (EDB), posed three intriguing questions concerning the changes in employment. The questions we need to ask ourselves are: (1) Can my job be automated, (2) Can my job be done anywhere, and (3) In an age of abundance, is my job still in demand? Our answers could give us a sense of what we want to learn and how we may want to learn to keep pace.

Given the complex and inter-linked changes in many dimensions (social, economic, geopolitical, technological, cultural, etc.), it is difficult to predict what the "brave new world" will be like with absolute accuracy. However, one thing is clear. There is a growing consensus that our students must be sufficiently purposeful, confident, agile and resilient to navigate this VUCA (volatile, uncertain, complex, ambiguous) future.

An ideal outcome would be a student who can be successful in the workplace, find meaning in their success, and is committed to sustainability and service to Singapore and the wider human community. Ultimately, a key goal of the SUTD education is to increase the human potential of each student regardless of their starting point so that they can fulfil their aspirations and be a positive force for change in Singapore and the world at large. There is no change in this commitment. One thing that I would like to emphasize here is that SUTD's education is values-based. SUTD's vision is to prepare students to be future leaders and innovators to serve societal needs and beyond. Our sense of bearing is important in a changing world.

2. That naturally brings us to the next question, Prof KK. How does SUTD prepare our students for the VUCA world?

There are essentially three aspects to focus on in terms of education. They are Knowledge, Competencies/Skills and Character Qualities. You can refer to the competencies listed in the 2016 WEF Report "New Vision for Education: Fostering Social and Emotional Learning through Technology" (Figure 1). We need to ensure that we include all three aspects in our education and that these are adaptive to the changing world. I will elaborate on each of these points.

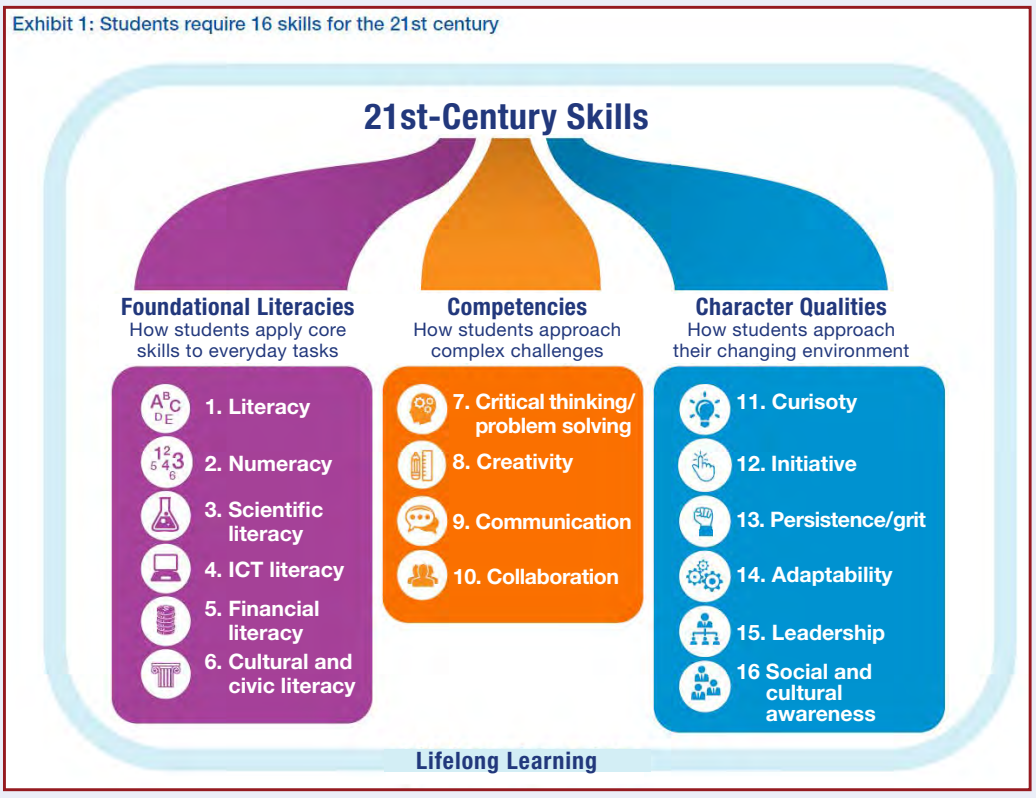

Figure 1: 21st Century skills required of students

SUTD was established in 2009 to be a pathbreaker in Science, Technology, Engineering and Mathematics (STEM) education. In terms of content knowledge, SUTD provides a solid foundation that allows students to pursue discipline specific interests in subsequent years. Our students are already taking advantage of our collaborative and interdisciplinary project-based pedagogy grounded on design thinking, technology, and Humanities, Arts and Social Sciences (HASS) to develop both foundational literacies (hard skills to solve one task) and competencies (soft skills to solve complex ill-defined problems). SUTD's unique pedagogy involving cohort classroom, project-based learning, capstone, and others is an excellent scaffolding for us to further strengthen competencies, particularly the "Big D" (innovation by design) element. This introduces and reinforces learning to learn skills, and fosters agility and resilience in our students.

Competencies require a learning environment that continuously nurture and reinforce desired traits such as creativity, collaboration, and communication across all subjects and all years so that they will become hard-wired habits. These opportunities are engineered into our curriculum and design projects. Two advantages are that (1) learning happens in a safe "fail forward" environment, and (2) learning happens over multiple projects and experiences. It is difficult to simulate these learning experiences in bite-sized "learning on demand" or "just-in-time" learning environments which are characteristic of the workplace and among lifelong learning providers. Hence the undergraduate years will be very useful for our students, and we will continue to build SUTD to provide the right learning opportunities and culture.

It is also useful to observe that a lifelong learner has limited time and therefore, limited white space to reflect and strengthen their ability to self-direct their learning journey as part of a larger purpose. The 5th row is effectively a white space for students to learn from each other, to exercise leadership, to interact with a diverse community beyond SUTD, and to grow cultural/social awareness among others. Ideally, our students should gain a better sense of their personal bearings, their strengths and limitations, their relationships with peers, and their place in the community and the world through our SUTD education which provides both formal and experiential learning opportunities.

In a nutshell, SUTD adopts a "circular education" concept in its learner-centric pedagogy (Figure 2). This is where SUTD's model with the Big D design framework differs from one without such a framework. The Big D design framework allows students to learn through creation. Upon creation, students share the knowledge with society or beyond, and this authentic learning experience provides holistic new learning and even creation of new knowledge and ways of doing things. Possibly, SUTD students would be able to create the future jobs that do not exist today! I think that this creative learning is very critical in instilling necessary traits such as agility and resilience to thrive in a changing VUCA world.

3. Could you elaborate more on these initiatives towards future plans at SUTD?

We are currently working on several new initiatives. There is a lot of youthful energy and imaginative power in the SUTD community. The SUTD community is working with me to develop a "Learn and Work 2030" framework that will guide the next phase of our growth. The framework will be agile, inclusive, and responsive to a fluid external environment, but it will be undergirded by "constants" that we are confident will not change.

SUTD aims to build a “Better World by Design”. A new centre called designZ has been set up to coordinate and increase our emphasis in Big D education. Design thinking will go beyond designing products/services that improve lives (economic value). Our students will be encouraged to “design” themselves and the community to contribute to a better world (social value). Our goal is for all students to strongly distinctive as a result of this design DNA.

We are also working on a new “campusX” initiative which looks at how new technologies or existing technologies can be used to enhance the quality of teaching and learning at SUTD and beyond. This will help us to refine and implement SUTD pedagogy more effectively in the changing learning environment. The pandemic has shifted teaching (and the way we live, work, play etc.) to be more online and this means that we have to redesign our mode of delivery. We do not want to just substitute face-to-face to online mode but want to create learning environments that are more personalized and more enjoyable. It is important to emphasize here the campusX is learner-centric and will consider leveraging on learning science as much as enabling technologies to make the SUTD learning experience as enriching and rewarding as possible.

Taking a global perspective, climate change and sustainability are widely viewed as the existential challenge of our generation. The latest Intra-governmental Panel on Climate Change (IPCC) report has urged for immediate and urgent actions. It is SUTD’s moral imperative to engage and contribute to Singapore Green Plan 2030 and the global sustainability agenda. This will be carried out through a SUTD Sustainability Plan (SSP) that stands for commitment to sustainability by every member of our SUTD community based on three broad principles:

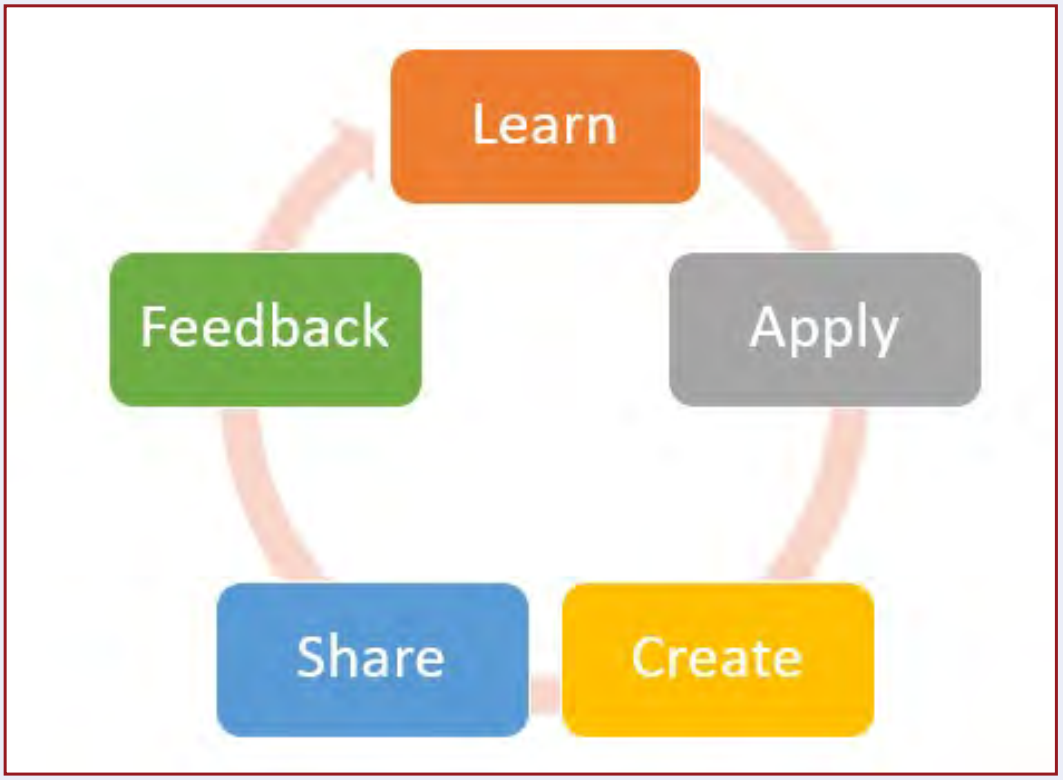

Figure 2: Circular Education

1. SUTD's mission of a "Better World by Design" will include a "More Sustainable and Happier World by Design."

2. Our success will be measured by sustained actions and by all SUTD members engaging with the SSP through education, research, and the way we learn, work, live, and play.

3. Our ambition is to impact our campus, nearby communities, Singapore and the world by seeking synergy with all like-minded partners.

We will also develop more purposeful programmes for 5th row so that our students contribute to a better world in two concrete ways. First, we will be launching our SUTD Sustainability Plan that articulates an exciting vision on how we can: (1) nurture leaders that will act and harness the collective will of the community to act, and (2) co-create impactful and lasting solutions with a coalition of partners in support of the Singapore Green Plan and the larger UN sustainability goals. Second, a better world must start with a better SUTD and Singapore as our local community provides abundant opportunities for students to contribute to building social capital and building their character qualities in the process of doing so. In short, a "Better World by Design" includes a "More Sustainable and Happier Singapore by Design" and our students should be inspired to do this, because SUTD and Singapore should be regarded as their home regardless of nationality.

I am excited to engage the SUTD community on these exciting and meaningful initiatives.

4. You mentioned "reimagining" education. What do you see as the New Normal for Higher Education and SUTD, in the Covid endemic era?

The ongoing pandemic has significantly disrupted all human endeavours, education included. The term "New Normal" conveys a sense of normalcy that will be different from the past but nonetheless we can settle comfortably into another new routine. In my opinion, it is too early to predict what it is going to be. We may emerge from the pandemic into the "Same Normal", "New Normal" or "Never Normal".

The pandemic is unfolding and no one has a clear line of sight on how it will evolve and for how long. However, two big changes are already in motion – one digital and one environmental. These external changes will not go away whether it is "Same Normal", "New Normal" or "Never Normal". The rate of these changes and the rate at which we need to adapt and respond to these changes may be affected by the pandemic or endemic.

5. Given that we cannot predict the new norm, how is SUTD planning to move forward in reimagining its education, with particular focus on curriculum and mode of delivery.

Digital technology and digital economy are going to be important aspects in redefining and reimagining education. First, digital technologies have matured and second, they are evolving to produce new products and services, new connectivity and systems, new experiences and even new behaviours (individual and organisation). Digital economy will shape the needs of the workforce and hence, what we teach.

In terms of curriculum, digital skills are already highly valued in the workplace. Our SUTD students are already well positioned to take advantage of the new opportunities emerging from the digital economy, but we are constantly innovating to further prepare our students to excel in high value industries. One example is the introduction of the "Design and AI" programme in 2020.

We are also working to deepen our integration with the industry to ensure our curriculum and our faculty continue to stay abreast of ongoing industry transformations and to shorten the industry-academia knowledge and curriculum loop. Our students and faculty are already engaged with the industry in a substantive way in the capstone project. More will be done to increase the porosity between the university and the industry to prepare for new work and new ways of working.

Another dimension to the digital economy is the increasingly pervasiveness of smart automation that displaces certain jobs. One example is "lights-out manufacturing", referring to fully automated factories that require no human presence on-site. Jobs requiring creativity and high human touch are thought to be more future proof. SUTD's emphasis on design (innovations) and serving societal needs (human centricity) is also a clear advantage in preparing our students to thrive in this digital economy.

The second concerns the transformation of how higher education is delivered. The traditional learning environment – the classroom model – where students gather to a single physical location at a predetermined time to engage in learning activities led by or facilitated by one or more instructors is increasingly challenged by the same digital technologies that are transforming the economy. Alternative massive open online courses providers (e.g., Coursera, edX) are making palpable headway in this transformation. As an indicator of their value, a leading educational technology company 2U bought edX for USD800 million in June 2021. We see this as the beginning rather than the end of the transformation.

The entire learning environment and experience are being re-imagined, because many digital technologies are converging to make the cyber- physical environment a reality in the foreseeable future. The time frame for this to happen is unclear, but a decade or two is entirely possible. This is called a Metaverse – "a collective virtual shared space, created by the convergence of virtually enhanced physical reality and physically persistent virtual space" as described by Wiki. This is not science fiction. The biggest technology companies such as Facebook and Microsoft have already initiated Metaverse projects: https://edition.cnn. com/2021/08/08/tech/metaverse-explainer/ index. html. The future of education is going to be very different.

In SUTD, we have initiated a campusX initiative to explore applications of a cyber-physical learning environment. A group of 50 faculty and staff members are currently involved in the campus initiative in developing and testing out the efficacy of new technologies or innovating new techno- pedagogies for teaching and learning.

There are many good reasons to pursue the campusX initiative, but one can easily reflect on the Orwellian undertones. We are clear at the onset that we need a "prime directive" to govern the development of campusX centred on the learners and the instructors. This goes beyond data protection and privacy, cybersecurity, and other compliance issues related to good governance and ethics. The campusX's prime directive requires all participants to align with three core principles: (1) to create a safe, inclusive, and enjoyable space to learn, interact, and 'fail forward", that is to learn from failures, (2) curate a personalized learning journey that is optimal in learning outcomes and learning experience. This can be for individualised and/or collaborative learning, and (3) provide

a living lab for our SUTD community to experiment and innovate teaching and learning that are creative, empathetic, and ethical. This will prepare our students for the future of work and workplace, technically and socio-emotionally.

We, at SUTD, have pioneered an effective interdisciplinary, design-centric, project-based learning over the past decade. SUTD will continue to a pathbreaker in the next decade by strengthening our Big D through designZ and initiate new ways of learning such as campusX among others. With SSP, we hope to instil a higher mission in our students through realization of our SUTD's value of a "better world by design" that includes a "more sustainable and happier world" by design.

Charles Dickens wrote in "A tale of two cities": "It was the best of times, it was the worst of times." In SUTD, we promise the future of our higher education will be the best of times.

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REFLECTIONS ON CYBER-PHYSICAL LEARNING

BLENDED LEARNING APPROACH IN COMPUTATION STRUCTURES COURSE DURING THE COVID-19 PANDEMIC

DR. NATALIE AGUS, INFORMATION SYSTEMS TECHNOLOGY AND DESIGN (ISTD)

In the Fall of 2020, the Computation Structures (50.002) teaching team came up with a blended learning approach [1] to cope with various safe management measures that were in place due to the COVID-19 pandemic. 50.002 is a core course conducted in Term 4 of the Computer Science and Design (CSD) bachelor's degree program by faculty from the ISTD pillar. The course introduces students to the architecture of digital systems, emphasising the structural principles that are common to a wide range of digital technologies. This is a required course for all sophomore CSD students. There were 180 students enrolled in the subject at that time.

50.002 is known to be a demanding course for CSD students. The course relies heavily on both hardware and software. In the project component, students, working in groups of five, are tasked to design and build a prototype of a hardware-based game machine, similar to those seen at game arcades. This project thus requires students to apply the digital systems architecture concepts taught in this course in a practical setting. As a result, it is no surprise that 50.002 is known as one of the toughest CSD subjects for the students. This is typically seen in the end-of-term feedback, where many students report that the workload in this course is barely manageable.

Before the Covid-19 pandemic, lessons in our course were conducted in cohorts of up to 60 students each, and the entire course had 3 - 4 cohorts per batch of students. We met each cohort three times a week. The first two sessions each week were lecture sessions, where each session was 90 minutes long, and was conducted in cohort classrooms. The third session of the week was a Lab Session conducted in the Digital Systems Lab (DS Lab) to enable students to gain hands-on experience by applying the topics that they had learnt during the first two sessions of the week. Lastly, students also regularly contacted the instructors for small-group consultations due to the heavy workload of this course. The Covid-19 pandemic meant that we were unable to stick to these routines during the Fall of 2020. The prevailing safe management measures meant that we could only accommodate a maximum of 25 people in the DS Lab, including the instructor, teaching assistants and students. Lessons involving more than 50 students also had to be moved online, thus we were also unable to conduct the usual lecture sessions on campus. To cope with these measures and yet maintain the effectiveness of teaching and learning, our teaching team designed a four-stage blended learning approach. In this article, we describe our approach. This approach was welcomed by positive feedback from the students and our end-of-term course feedback showed good ratings similar to that of pre-pandemic situations.

Four-stage Blended Learning Approach

OVERVIEW

We restructured our weekly lesson plan in four stages. Students first watch pre-recorded video lessons and read the lecture notes. They then attend two online tutorials, followed by a lab session held on campus. The final stage involves watching post-lecture summary videos to wrap up the learning for the week. This is illustrated in Figure 1. Our goal in this approach is to combine mix-modes of web-based technology with traditional established classroom forms that require the physical co-presence of teacher and students to achieve balance between access and flexibility during the pandemic [1].

Weekly Lesson Structure

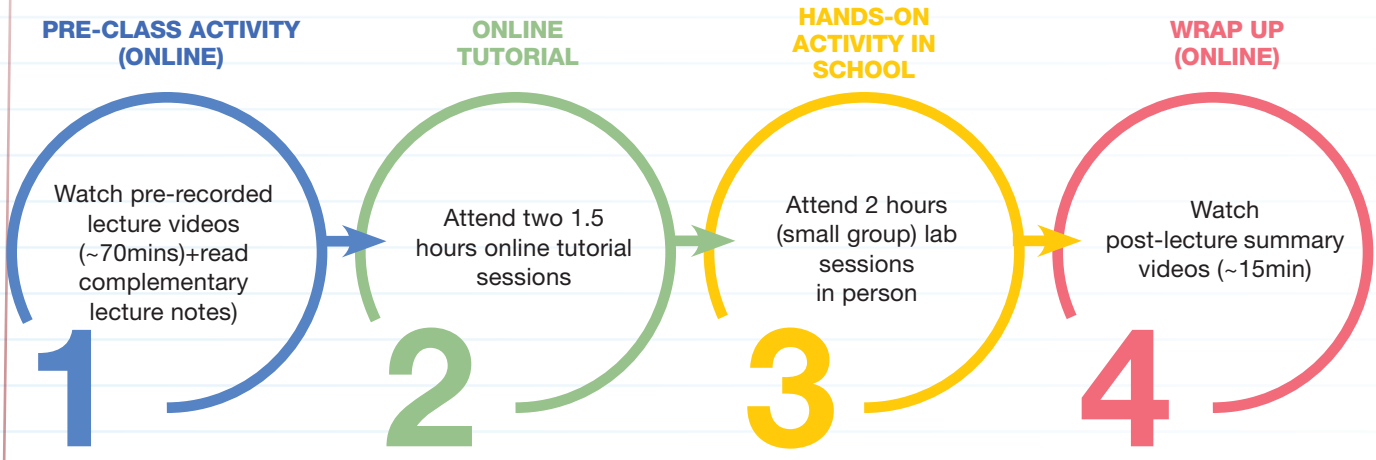

Figure 1: Our weekly lesson structure, based on the blended learning approach

Stage 1, 2, and 4 are online, and Stage 3 is conducted physically in the DS Lab. As the hands-on lab sessions are an integral part of the course, we conducted them in smaller groups of 20-23 students to comply with safe management measures. Thus, we had to divide the students into 8 cohorts (compared to 3 to 4 cohorts previously), amounting to 16 hours of lab time alone per week. With this arrangement, each student could still have the opportunity to attend lab sessions on-campus and meet their instructors for two hours per week, compared to the usual five hours per week before pandemic. To keep the teaching load manageable for the faculty with increase in lab hours, our online tutorials were attended by all eight cohorts of students, instead of conducted for each cohort previously. The study by Xie et al. [4] had also taken a similar approach successfully, by introducing the basic concepts and illustrating it physically in the classroom, then practicing the typical content in the virtual lab designed, and finally going to the lab to do physical experimentation. The main difference was in how the basic concepts were delivered. Our approach demanded a more independent attitude from the students to get on board with the materials of the week (stage 1) before applying what they have learnt during the online tutorials (stage 2). We elaborate on each stage in the following sections.

Stage 1: Pre-class Activity

To increase engagement with our students online, our online sessions were divided into two stages: the pre-recorded lecture session (stage 1) and live tutorial session (stage 2). For each week, our teaching team prepared a set of lecture notes and a pre-recorded instructional video. This was analogous to the traditional lecture-style lesson delivery where students were mostly passive listeners. We incentivised students to watch these videos by conducting a pre-class activity via our learning management system, eDimension. Students were tasked to answer short quizzes before Monday of each week, amounting to a total of 5% of their total assessment grades over 10 weeks. Each weekly quiz consisted of five short questions based on the instructional videos and the lecture notes, and students were given three attempts for each quiz. Each quiz has the same set of questions, and the score is taken from the latest submission only.

Stage 2: Online Tutorial Session

During the online tutorial sessions (stage 2), our instructors gave a summary of the topic of the week in the first 30 minutes. This was followed by a discussion on selected tutorial questions. About 70% to 80% of our students join these sessions regularly each week, even though attendance was not compulsory. We found that attendance at morning sessions were in general lower than those in the afternoon or evening time.

All our online tutorial sessions were conducted through video conferencing via Microsoft (MS) Teams. Students could type their questions, comments, and answers in the chat or unmute their microphones to speak up. We saved each lesson's video to enable students to review each tutorial session at their own time. With students having completed stage 1, this ensured that students came to the online tutorial sessions prepared. We thus ended up with a lively discussion at each session. The screenshot below (Figure 2) shows a lively scenario with hundreds of comments from the students attending the session:

Figure 2: Screenshot of statistics of comments posted by students during online tutorial session conducted via Microsoft Teams

Typically, at the beginning of each session, a small number of students were active with their questions, and more students join in as the session progressed. Since our instructors did not repeat the content of the pre-recorded lecture materials, students were encouraged to attend the sessions to test their own understanding and clarify their doubts. We also observed several students privately message our undergraduate teaching assistants and the other instructors on standby to ask for help, as they felt that they did not want to interrupt the online tutorial session.

Stage 3: In-School Lab Session

In stage 3, students attended one two-hour lab session on campus (Figure 3). The lab activities were designed to reinforce their understanding on the topics taught that week. It was also a chance to consult their instructor in-person. During each lab session, apart from the instructor, we also had at least one undergraduate teaching assistant present to attend to queries. We also live-streamed each lab session and archived the recordings. These recordings helped some students who were required to stay at home due to medical leave or who were placed on Stay Home Notice (SHN).

Figure 3: Students attending in-school a lab session on campus in the DS Lab

Stage 4: Post-class Activity

Finally, in stage 4, we published short (10 to 15 minutes) videos to summarize the learning objectives of the week. These videos served as a quick revision and checklist to help students ensure that they do not miss any major learning points.

MS Teams Classroom and Undergraduate Teaching Assistants

We utilised MS Teams as a common online platform (Figure 4). We used its videoconferencing feature to deliver the online tutorial sessions (Stage 2). We used its channel feature to post course announcements. We also created separate channels for each week for students to post their questions, thus creating a repository of student queries. This allowed our teaching assistants and instructors to respond to questions posted as shown in the screenshot below:

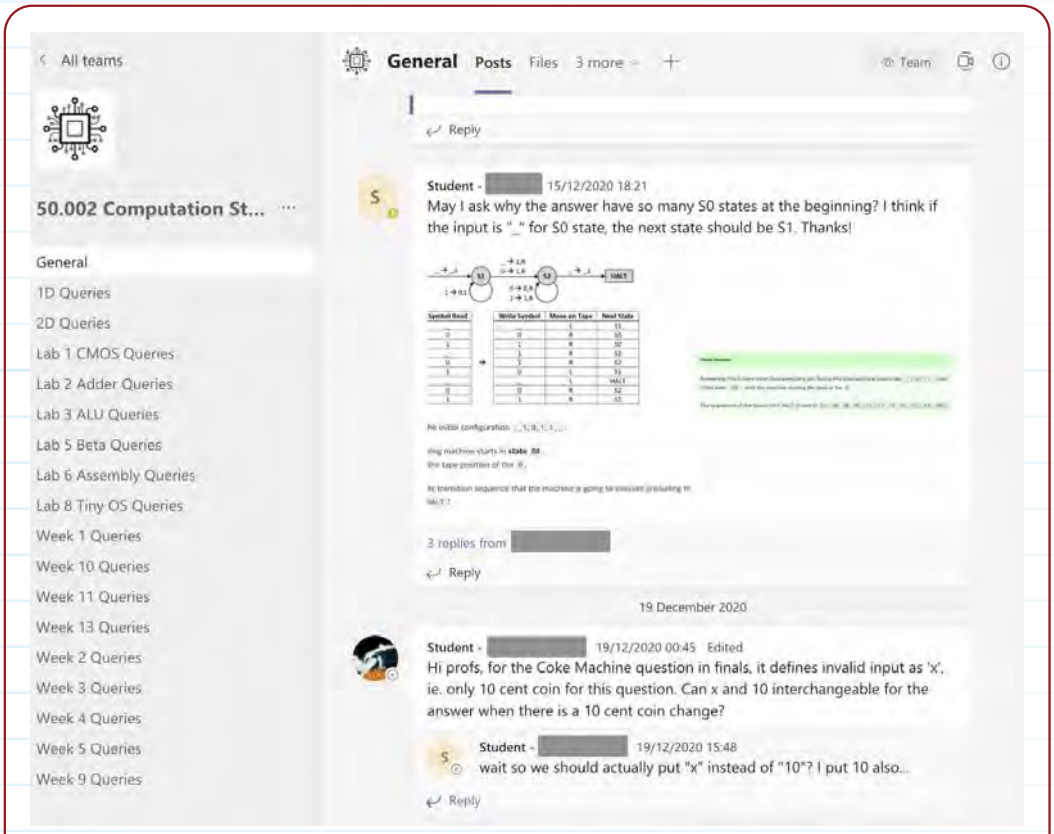

Figure 4: A screenshot of typical questions posted by students in the Microsoft Teams classroom

As posts in the channels were not anonymous, some students were reluctant to post their questions. Thus, we also encouraged students to chat with instructors directly in MS Teams at any time to consult their doubts. The instructors also called students directly via MS Teams if their questions required more elaborate explanation. This allowed us to connect with the students better even though we only meet them in person for two hours per week.

To further support the subject, we hired twelve undergraduate teaching assistants (UTAs). They were important for two reasons. Firstly, UTAs were generally perceived as approachable by their juniors, and therefore students usually approach them first in times of doubt. Secondly, as they had taken the subject before, they have their own understanding of common mistakes that students might make, which is a perspective that faculty would not possess. From their previous experience, they could also give better advice to their juniors on how to study for the subject and be better at time management.

Students' Feedback

To gauge the effectiveness of our approach, we analysed the end-of-term feedback scores (Table 1). The table showed the percentage of students assigning a rating of 4 ("Good") or 5 ("Very Good") on a five-point Likert scale. We saw a slight drop in the overall rating of the course and students' evaluation of the active learning approach, but the ratings remained high and the difference was not statistically significant. Studies made by Monk et al. [5] to investigate the effectiveness in a blended learning approach also showed that this change in the mode of delivery did not seem to have affected the students' final grades adversely.

Table 1: Percentage of students in the course assigning a rating of 4 ("Good") or 5 ("Very Good") in the end-of-course feedback.

	2020	2019
This course involved me in active learning experiences.	86%	92%
Overall rating of the course.	75%	88%

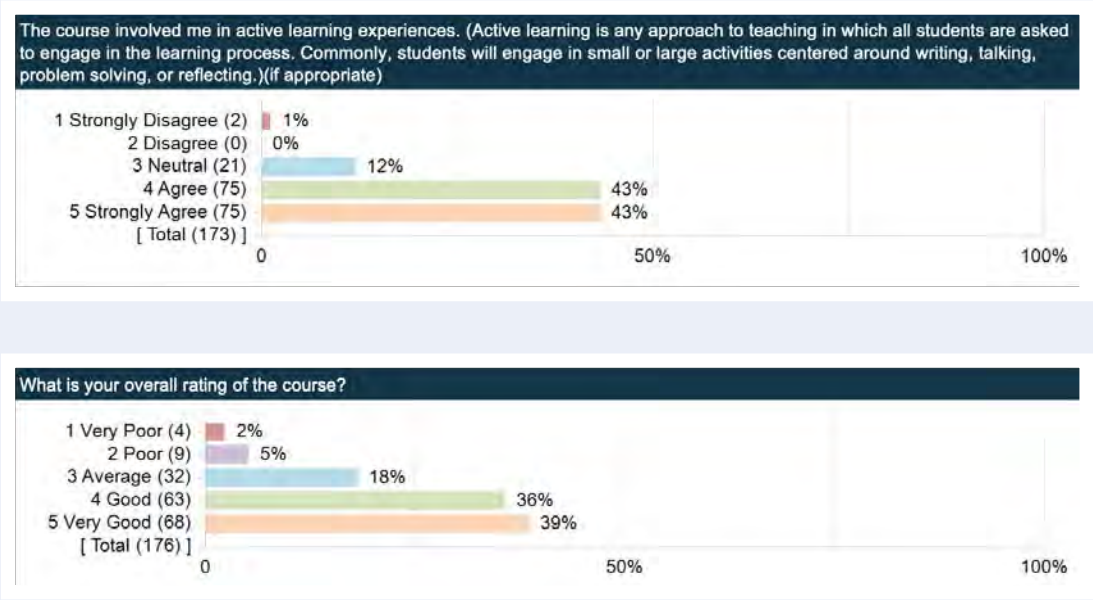

Figure 5: Feedback result from 50.002, 2020, end-of-term course survey with 180 students enrolled

This is comparable to our results one year prior in 2019 before the COVID-19 pandemic. It is interesting to note that although the % of both "Good and Very Good" is higher in 2019, there is relatively more "Very good" than "Good" in 2020. In 2020, there are more "Poor" rating as well. We can observe more obvious extremes in 2020 as opposed to 2019. This suggests that students' responses are more divided in this blended learning approach as opposed to the traditional face-to-face teaching approach.

Figure 6: Feedback result from 50.002, 2019, end-of-term course survey with 150 students enrolled

In the responses to the open-ended questions, many remarks were positive. Some students remarked that the course was complete and well organised, and that the pre-recorded lecture session (stage 1) helped them to learn independently and be prepared for class. Despite the limited amount of in-person interactions between instructors and students per week, none of the remarks suggested that the students felt any sort of disconnection that we feared would happen in a full online learning environment. However, it was worth noting that some students still prefer face-to-face learning if given a choice, hence confirming previous studies [2, 6].

Reflection

Although the blended learning approach was largely successful, some students still feedback that the workload of the course was too heavy. To address this, we could have distributed more hardware kits per group as the situation meant that it was difficult for group members to meet physically to work on their project. It was also important to adapt to the situation and the needs of our students swiftly by keeping regular contacts with each group via our MS Teams classrooms or chats. We also learnt that it was important to continuously remind our students both offline and online to always catch up and start their projects early, thus avoiding situations whereby their workload snowballed such that they had to submit half-baked quality work just to meet the deadlines. The usage of MS Teams had made it very convenient for our students to reach out to us for consultations. Our availability for consultations, whether or not there was a pandemic, remained crucial [3]. Studies by George [3] found that email consultations were used by students only after other avenues for communication had been exhausted, and therefore it was important to provide additional support by allowing our students to initiate online chats and video conferencing with instructors outside of designated class hours.

The pandemic curtailed laboratory access, and we had to put measures in place to manage the situation. Before the pandemic, our students had the freedom to access the DS Lab at any time; 24 hours a day, 7 days a week. It was a safe space for students to plan their projects, conduct discussions, solder their prototypes, or utilise other electronic tools for debugging. This was no longer possible during the pandemic due to the safe management measures. We had to limit access to office hours, and stagger the access among different groups. In the two weeks before the project was due, we increased the amount of access hours beyond office hours. We deployed UTAs to assist with attendance-taking and to ensure that the maximum number of students present was not exceeded. We realised that demand for lab access would be high near the project due date. In order to manage the demand, we also regularly contacted each project group to check on their progress and reminded them to manage their time wisely, and inform us immediately if they required urgent access to the DS Lab.

The live streams and recordings of the lab sessions were important as it helped students who could not travel to campus to follow the proceedings. Other students, who had mostly online lessons throughout the day,

did not wish to travel to campus solely for a two-hour lab session. Sometimes, technical problems occurred, such as the stream stopping suddenly or the lecturer moving out of the frame of the camera. Nevertheless, we learnt that comprehensive, self-explanatory lab handouts and clear instructions complemented these streams, and had definitely helped to ease some doubts that students might have while viewing the live stream remotely. As the term progressed, we updated our lab handouts for clarity. We also actively updated all our lesson notes and plans based on direct feedback from the students. This rapid feedback-improvement cycle that happened on an almost daily basis tremendously helped us to deliver this content-heavy course during the pandemic.

We noticed a spike in both view count and watch time of our short summary videos (Stage 4) twice. The first spike was on the weeks when the lessons were taught and then the second spike was during quiz week. For example, here are the view analytics for topics in Week 2 and 4. This shows that some students, approximately 40-50% of the cohort spend the time to watch the summary videos on their own even though it is not graded like the pre-class activities (Stage 1).

Figure 7: Logic Synthesis (Week 2) view analytics

Figure 8: Programmable Machines (Week 4) view analytics

Summary

In this article, we described how a four-step blended learning approach was implemented for 50.002 in Fall 2020. The lesson component went completely online, but we retained physical on-campus lab sessions and the 1D project, both of which were critical to students' learning in the course. We implemented live streams of our lab sessions for students who could not make the trip to campus. Instructors kept in constant contact with students, answering their doubts and providing regular reminders. All these worked together to provide students with a successful learning experience in spite of the Covid-19 pandemic.

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LEARNING THROUGH ASYNCHRONOUS ASSIGNMENTS IN A HUMANITIES CLASS

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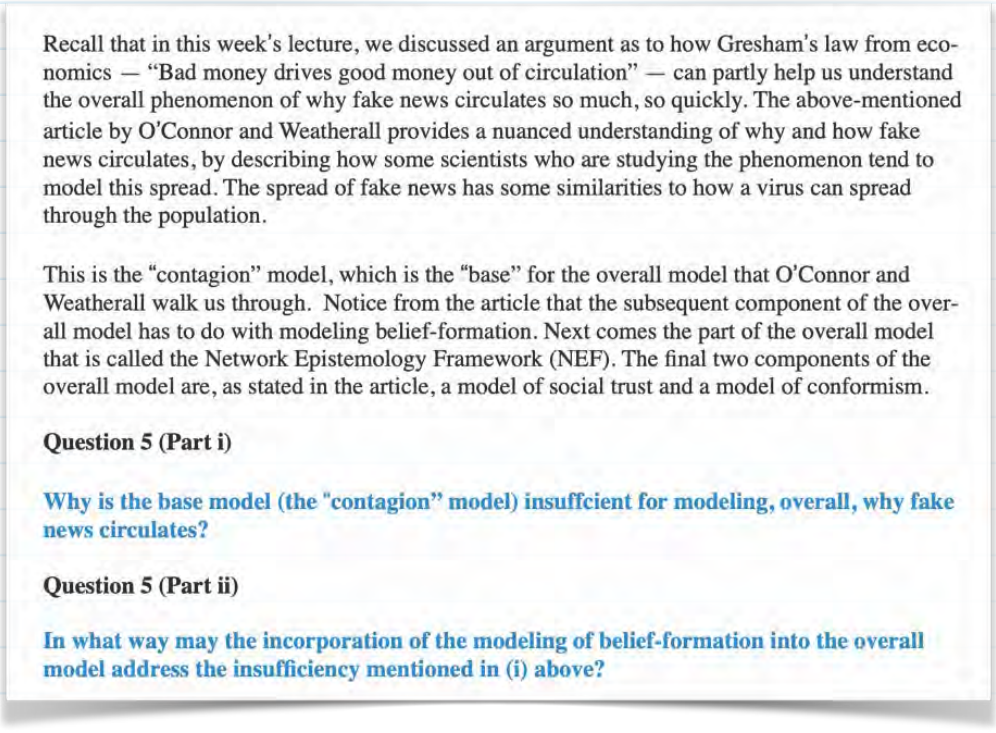
As the pandemic shifted teaching to online-only sessions, I noticed that in-class discussions conducted synchronously became less lively as students adjusted to the 'new normal'. This is possibly because physical isolation increases hesitancy on the part of students, keeping them from being as expressive as they are in class sessions in which they are present physically. Anecdotal evidence from instructors seems to support this. For example, Beth Beason-Abmayr, a teaching professor at Rice University, mentions that "[w]hen Rice University moved all classes online due to the COVID pandemic in Spring 2020,… we observed that students did not turn on their cameras unless we asked them to and definitely seemed more hesitant to answer and ask questions in Zoom." [1]

Observing this made me rethink class assignments and to use asynchronous (albeit collaborative) tasks to facilitate some of the learning on the part of the students that would ordinarily have occurred synchronously in class through discussion. It has also made me reflect on which kinds of learning may be better facilitated through asynchronous assignments and which kinds not so much — especially in the context of classes in the humanities, in which we try, as instructors, to teach students to think critically, no matter what the specific subject content of the class might be.

With examples drawn from my 'Form and Content in the Arts, Science and Society' course for Summer 2021, I am going to draw some tentative conclusions. This is a course that is part of the Digital Humanities minor and Design, Technology and Society minor within Humanities, Arts and Social Sciences in SUTD, and regularly draws more than fifty students, spread over two sections. Among the learning outcomes of this course are: To develop the students' imaginative ability, so that they can understand how thoughts can be expressed across different forms and genres; to develop students' ability to understand how similar themes occur in different disciplines; and to acquaint students with the basic principles of epistemology, that is, of the science of what constitutes knowledge in different contexts. Thus, students in the course get to critically appreciate different forms of knowing such as propositional and predicate logic on the one hand, and associative thinking on the other hand, and become acquainted with the strengths and limitations of both these forms of knowing. Learning about how to reason with epistemic dependences, as well as how to reason analogically, are therefore important components of the course, and my observations pertain to the challenges of getting students to appreciate these two forms of reasoning in the environment of blended learning. Let us consider a set of questions (Figure 1), taken from a homework assignment for the course.



Recall that in this week's lecture, we discussed an argument as to how Gresham's law from economics — "Bad money drives good money out of circulation" — can partly help us understand the overall phenomenon of why fake news circulates so much, so quickly. The above-mentioned article by O'Connor and Weatherall provides a nuanced understanding of why and how fake news circulates, by describing how some scientists who are studying the phenomenon tend to model this spread. The spread of fake news has some similarities to how a virus can spread through the population.

This is the "contagion" model, which is the "base" for the overall model that O'Connor and Weatherall walk us through. Notice from the article that the subsequent component of the overall model has to do with modeling belief-formation. Next comes the part of the overall model that is called the Network Epistemology Framework (NEF). The final two components of the overall model are, as stated in the article, a model of social trust and a model of conformism.

Question 5 (Part i)

Why is the base model (the "contagion" model) insuffcient for modeling, overall, why fake news circulates?

Question 5 (Part ii)

In what way may the incorporation of the modeling of belief-formation into the overall model address the insufficiency mentioned in (i) above?

Figure 1: Excerpt from homework assignment on reasoning

In the case of the above questions, the outcome of the learning activity is for the student to understand the reasoning of the article that they have read. They are to achieve this by taking apart the mechanism of the article's argument. This provides the students with practice in thinking critically. Their success in accomplishing the task depends upon their ability to understand, within the author's argument, the epistemic dependency founded on the epistemic basing relation [2], which is the relation between a belief and a reason when the belief is held for that reason. In the above case, the "epistemic basing relation" is the relation between the belief that the "contagion" model is insufficient, and the relevant reason is that the "contagion" model, by itself, while providing an account of the mechanism of the spread of certain views, does not provide an account of how in the first place those views came to be formed. Whether the student is being asked to trace the argument of a writer (as in the above case) or to construct their own argument, purely logical procedures suffice to accomplish this kind of task. This kind of task does not require associative or lateral thinking, and so it can be easily accomplished by a small group of students or even a single student, working solipsistically on their own.

A task that requires associative or lateral thinking, on the other hand, would have needed imaginative leaps that cannot be accomplished purely through logical inference procedures. Such breakthroughs require a churning of ideas that is best undertaken socially. "Brainstorming", for example, is a common term for that activity. It is something that happens synchronously and collectively. This is why students find it much harder to carry out alone those tasks that involve reasoning via the discovery of (or — even more challengingly— the construction of) homologies or analogies. Also, among the two, non-homological analogies seem to pose the harder challenge. Let us start by seeing what a homology is. Figure 2 shows how I explain the concept of homology to my students. (It is part of a slide from one of my lectures for the class.)

The word "analogy" comes from a Greek word literally meaning "according to logos" — in this context, the Greek word means "according to a relation". At the heart of analogy is the recognition of a relation or an association between two disparate things. And homology, as we see in Figure 2, is a special kind of analogy in which the association made is not only between the things themselves but also between the processes in which they participate. The recognition of an analogical relation cannot be reduced entirely to an inference procedure but requires imaginative leaps and, to some extent, chance discovery triggered by serendipity. The recognition of this kind of similarity arises from our imaginative life and is usually facilitated by shared experiences of collectiveness. Arguably, this is the reason why path-breaking, outside-the-box discoveries tend to be made more often by people working in groups rather than by a lone, "heroic" person operating on his or her own. The same is true, although at a different scale and scope, for the discoveries through which students' learning proceeds. Requiring associative thinking rather than merely the execution of previously determined inference procedures, analogical thinking lies at the core of the humanities.

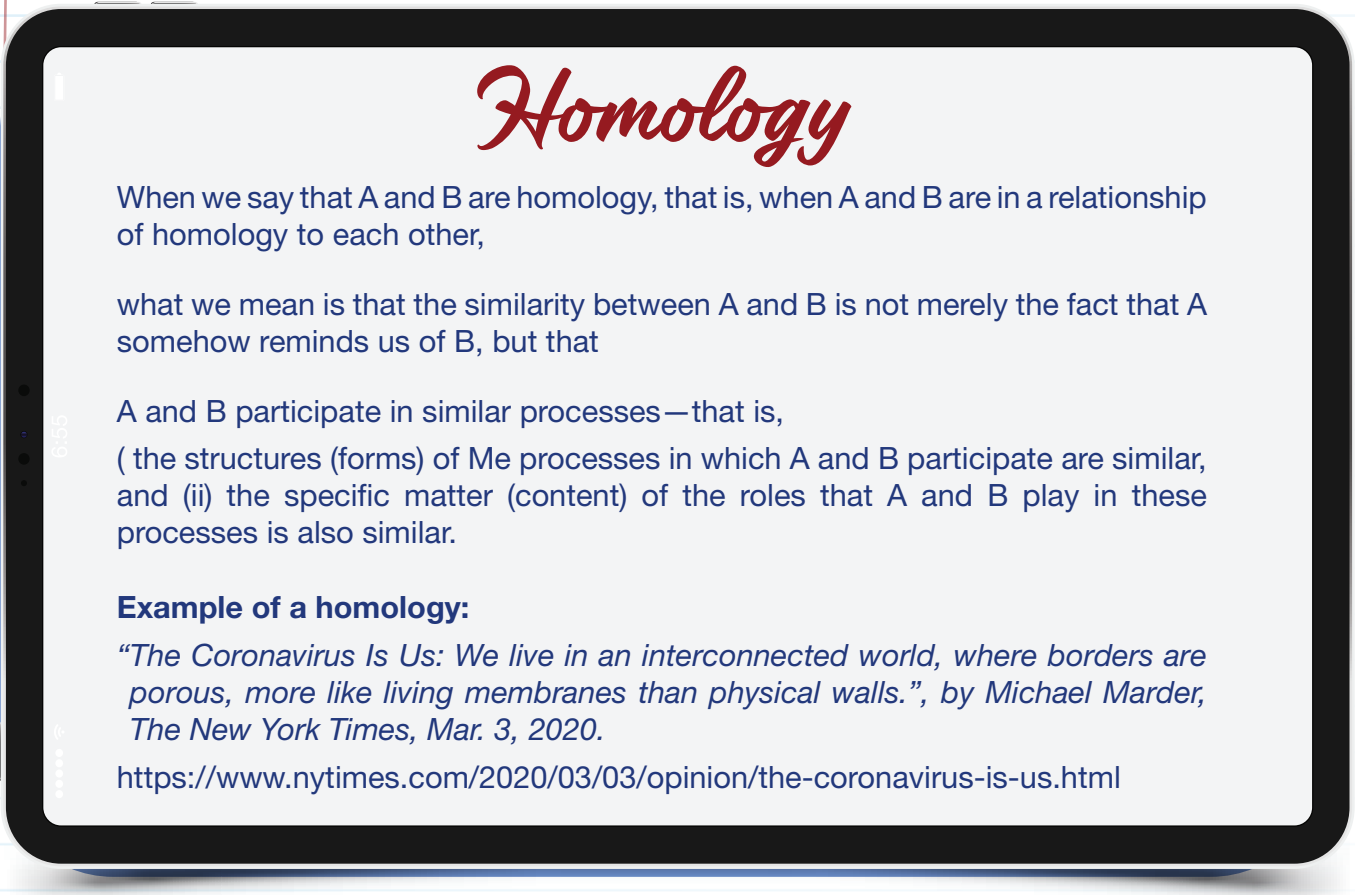
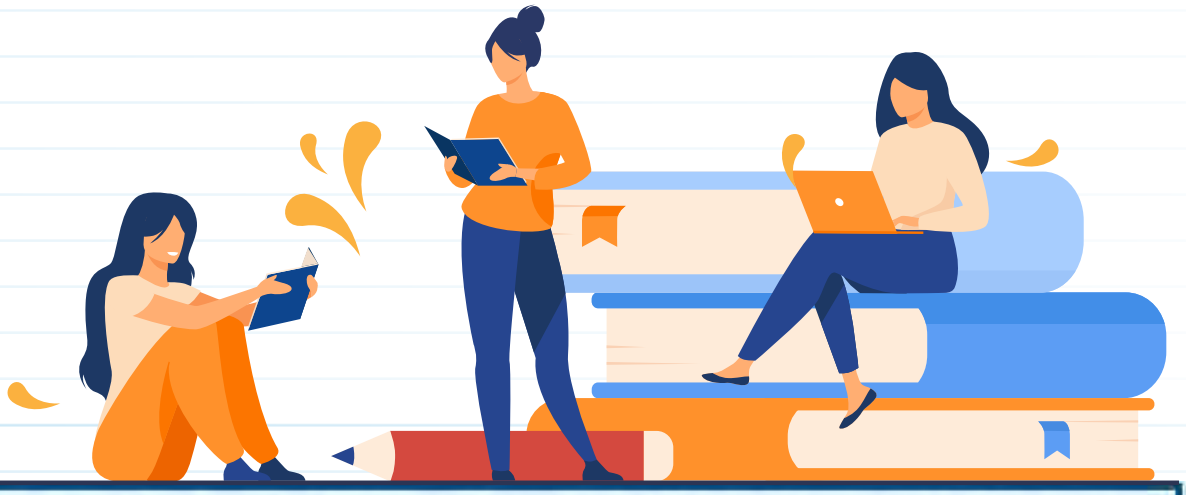


Figure 2: Example lesson slide on analogy

Analogical thought, thus, is a prime example of the humanist notion of finding affiliation and affinity with, and between, everything under the sun, no matter how strange or unfamiliar. As a character says, in Latin, in one of the plays by the Roman playwright Terence: "Homo sum. Nihil humani a me alienum puto." ["I am human. Nothing that is human can be alien to me."] In a world in which information can be found relatively easily, and in which routine tasks will be increasingly automated, the skill that our students are going to need the most during their careers will be thinking associatively and analogically— that is, the ability to see and create connections, associations and linkages easily and quickly. These are the skills that humans are good at (and machines are poor at), and so these are the skills that are going to be the hardest to automate (and therefore the most difficult to outsource to computers, even with AI).

In Figure 3 below, the italicized lines illustrate how, in a particular assignment, I use a leading question to help a student discover an analogy, and, in my comment on the student's answer, guide the student to perceive how what (s)he has hit upon is actually a homology. The answer given by the student is fairly typical of the answers that students give to this question. [The student's answer (along with my comments on it) is in bold font. The words in brown (colored for emphasis) are the student's, while my comment consists of the words in red.] The student mentions that (s) he thinks that "We could take this analogy farther…", and I show the student how it can be taken further by perceiving that the analogy is actually a homology. The reason that the student has grasped the analogy quickly is because this analogy is homological — rather than being based on a single point of associative similarity, the analogy in this case is structural and therefore the points of similarity are mutually reinforcing.



Review the chapter 'The Songwriting Formula' of the book The Creativity Code by Marcus du Sautoy. In this discussion of the algorithmic software called The Continuator, Marcus du Sautoy says that using the software showed the artist "aspects of his craft he had not accessed before". Do you think that this access into a previously inaccessible area that is discussed here similar to the penetration, discussed in Question 4 above, into "the deep unconscious"? Why or why not?

Answer: I agree that there are some similarities between this "access into aspects of his craft" and the "penetration into the deep unconscious". Although they are referring to different aspects, with the former referring to accessing knowledge about Marcus du Sautoy and how he composes, and the latter referring to being able to gain insight into how the DeepDream algorithm works, they are similar in the sense that they both give insight into an area that was previously unknown. We could even take this analogy further by saying that neural networks such as DeepDream are a simplified version of the human brain or vice versa. [In technical terms, what you're saying here is that one can extend this analogy into a *homology*; we will talk about these terms in detail after the term break, in the class session on the topic of analogy] Therefore, we can draw similarities between the knowledge gained about neural networks through DeepDream and the knowledge gained about humans' musical compositions through The Continuator.

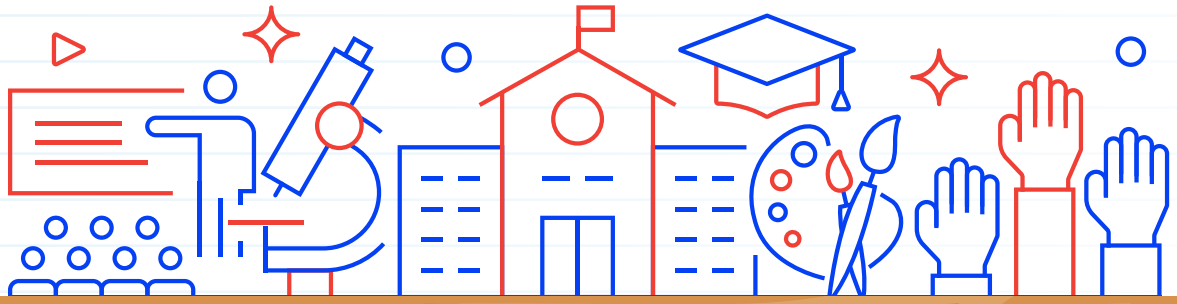
Figure 3: Excerpt from class assignment. Instructor comments are highlighted in red

Thus, my tentative conclusion is that, overall, in the blended learning environment that is likely to become a part of the "new normal", analogy-making turns out to be hardest to teach. (Analogy-making that involves homologies, however, is somewhat easier for students as homologies tend to be well-structured structured: once a student "gets" a part of the homology, the rest tends to fall in place more easily.) Learning that involves merely figuring out epistemic dependences, meanwhile, turns out to be the easiest for students.

All this suggests that, within a blended learning environment, when learning involves analogy-making, it may be especially important to assign the asynchronous assignments as group work rather than as individual work so as to enable students to brainstorm among themselves, triggering each other's imaginations within the group, which is more likely to make it possible for them to make the imaginative leaps needed to think analogically.

Acknowledgement

I gratefully acknowledge Paolo di Leo, Senior Lecturer in Humanities, Arts and Social Sciences at SUTD, for his valuable comments on an earlier version of this article.



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COMPUTER APPLICATIONS ASSISTING THE DIGITIZATION OF ARCHITECTURAL INSTRUCTION

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The transfer of the learning environment from an in-classroom, on-campus setting to a digital online environment at first may appear as an arduous task. At the same time, this presents a wealth of opportunities for expanding didactic teaching methods to ensure knowledge transfer. This brief article shall explore the transition of architecture-specific courses from an in situ, on-campus environment to a wholly digital environment, conveyed via the internet using the Zoom video conferencing software. In this article, how this software is used creatively for architectural instruction will be described and potential areas of further exploration will be identified, leading to successful knowledge transfer to students in this digital environment.

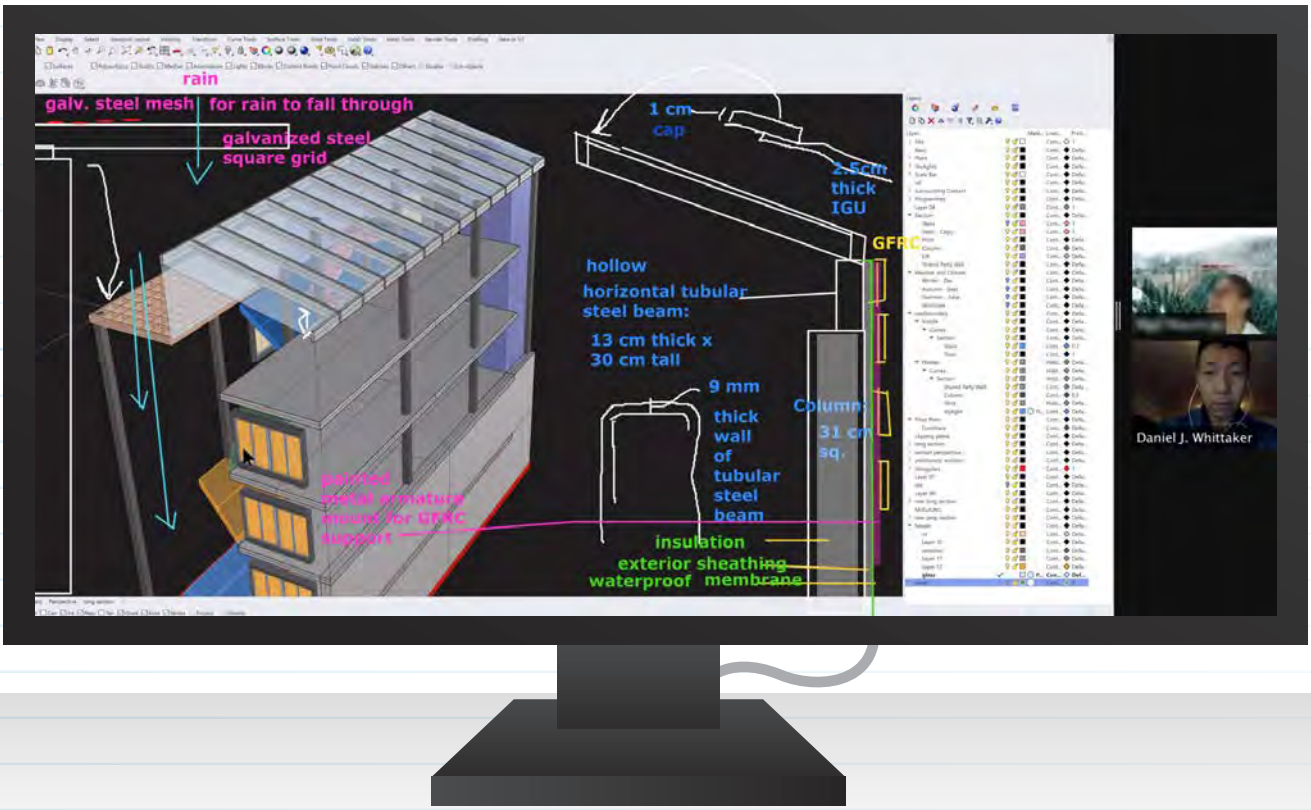

Figure 1: Student-generated isometric computer model of their theoretical project, with instructor comments overlaid upon the drawing

Architectural design education's core learning principles are taught in design studios via the production of theoretical projects where students are presented with imaginary clients that have realistic needs and at times, tangible, buildable sites. In order to envision what the future built environment could be, instructors convey ideas about how to effectively shape space that serves the user's needs via a variety of drawing methods. Traditionally, this was communicated to small groups on a chalk board or a dry-erase board. Likewise, one-on-one sessions between the instructor and a student led to the term 'desk crit', which refers to the instructor sitting next to the student at their studio desk and reviewing the student's drawings by giving a verbal critique and drawing new sketches over the student's drawings with translucent tracing paper.

Hence, the primary method of communication in architecture and sustainable design studio-project based education has traditionally taken place via physical drawings in face-to-face settings. Visual representation based upon plan, section, elevation, perspectival or isographic projection means are how designers are trained to convey their vision to their colleagues for buildings and spaces that are not yet tangible. Whether executed by hand using the medium of pencil and paper, or on a computer using a mouse and specialized software such as AutoCAD, Revit or Rhino—the act of two- and three-dimensional visual conveyance of an idea through two or three dimensional drawings has steadfastly remained paramount. Communicating ideas about how space shall be shaped, based on an agreed-upon set of criteria typically yields what is termed "the best design solution." In order to problem-seek and problem-solve design issues presented in the classroom, visual analysis of the drawing enables such complex tasks to unfold.

The onset of the Covid-19 pandemic has necessitated the implementation of various digital communication tools [1], whereupon physical adjacency is impossible and teleconferencing software on computing devices has provided the simulacrum of a studio environment. This paper shall briefly explore the various attributes acquired during this sudden transition and the numerous positive consequences of such new virtual visual communication between mentor and student in the realm of architectural design education.

During a design studio conducted on campus, the desk crit begins when the class professor or design mentor sits next to the student who has prepared a tangible drawing for review. The design critique then occurs when the professor places a translucent sheet of tracing paper on top of the student's drawing, and draws new lines, forms and notes upon the base drawing underneath. Gradually, a palimpsest forms whereupon numerous lines representing walls, paths, volumes of height, rays of light- for example- accumulate upon the tracing paper. Often, textual notes are also added for emphasis to underscore the desired design goals. This process of review, discussion and evaluation of the merits of a proposed design is only between the student and professor, due to the intimate nature of a small drawing produced on an A4-sized sheet of paper. Hence with this analog sketching and drawn critique method- scalability is typically unfortunately not possible. It is not easy to display small sketches to a larger whole-class audience. The limitation of useful and meaningful visual communication between two persons at a desk is reached; knowledge transfer beyond this sphere has proven to be difficult.

The advent of numerous digital communication tools has expanded the audience of desk crits, which were formerly discussions between instructor and individual students [2]. Utilizing the share-screen function of Zoom, any digitally produced image (typically a site plan, building plan, section, elevation or projected axonometric drawing) can be shared amongst the group and available for the entire class to view on the shared digital platform. Even hand-produced drawings can be digitally photographed and transferred to the online platform to be shared and seen among the entire class. This enables fellow classmates to see, with immediacy, the state of their fellow cohort's work and compare their own design challenges with the one currently being reviewed.

Due to the online nature of the projected work, the analog methods of the traditional studio desk crit cannot be used. Instead, the use of the 'draw' functions in Zoom replicates the act of improving a given student's design, for all to observe. This process then is captured through screenshots or saving-screen options. Subsequently, the image is transmitted via email to the student to review, post- critique, just as the piece of tracing paper in the past was kept by the student for their utilization to improve their design work.

With these contemporary digital mark-up tools [3] enabling both the student and the critic to draw atop the originally issued drawing, the newly-created drawing becomes a permanent digital record. This has infinite replicability, and hence, is saved by the professor and presumably by the student. This powerful tool- a digital annotation of what design changes were requested at a moment in time- now lies in the possession of both student and instructor, instead of just the student's project development papers. Hence, the real power of this array of digital ephemera occurs during subsequent weeks of the term, when the design explorations and changes that were requested earlier can be immediately recalled by the instructor, instead of formerly being in possession solely by the student. Likewise, the digital imagery has been broadcast to the entire cohort of classmates for further benchmarking and learning. [4]

A typical mid-level (second year) design studio meets twice a week with twelve students enrolled in the collective-themed design investigation process. During a four to six-hour session, ample time is available for both a 45- to 60-minute introductory lecture by the professor, which sets the theme of the day and week. The remaining time allows for an approximately 20-minute desk crit session with each student. When conducted online, the lecture tends to proceed quicker, with a faster cadence of slide image presentation to captivate the attention and sustain a finite period of intense listening by the student audience. Individual desk crits, which proceed on a one-on-one basis, interestingly, are conducted online in a near-identical fashion as the ones conducted face-to-face. This is likely due to the fact that the act of drawing by hand on tracing paper is nearly seamlessly replicated in the aforementioned digital Zoom environment.

Student response to this digital note-taking and digital record-keeping has largely been positive in terms of having additional reminders upon what was requested for changes for improving a given design. After conducting virtual desk critiques with a dozen students in the design studio, the resulting collection of screen capture images are emailed to the students after the studio. Due to the large number of such images, the instructor often forgets to include one or two images. Almost always, the affected students send a follow-up email requesting for the 'one additional note page' so they can make the desired changes. The student is now held more accountable for changes since there is a digital record of what was requested. In the past, in a physical design studio setting, since the student was the sole recipient of the drawings generated during the critique by the teacher/reviewer, if the student chose to discard the tracing paper, the record of what was requested disappeared. It was then solely up to the instructor to recall what changes were requested, without tangible evidence.

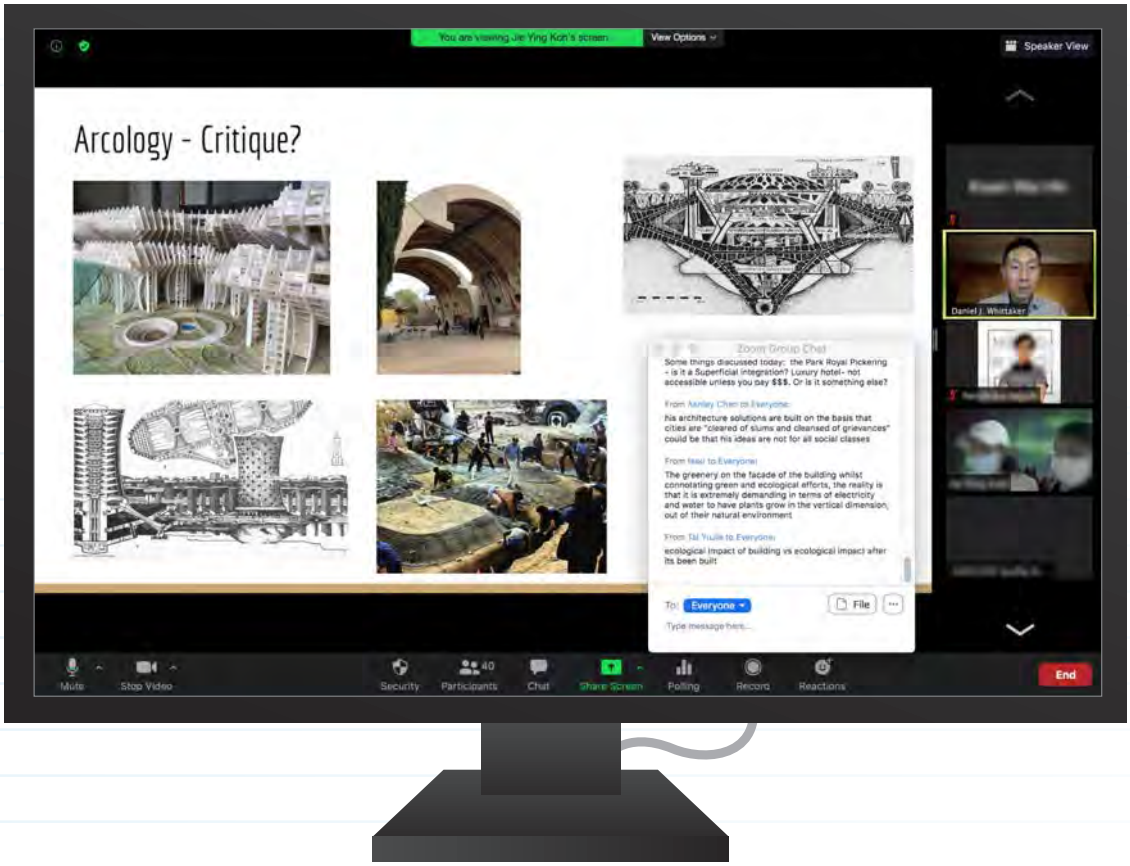

Figure 2: Paired student group presenting their analysis via PowerPoint presentation, with floating dialog window showing parallel discussion taking place among all of the fellow classmates

At times, this resulted in students disputing the requests for changes, and these disagreements were difficult to resolve in the absence of drawn evidence.

Hence, the digital imagery resulting from online architectural critiques is but one powerful feature emerging from using Zoom software to re-create a studio classroom environment.

A second major didactic tool which has emerged out of the use of Zoom encompasses the 'chat' function of the program. This discourse, which oftentimes literally occurs on the side of the Zoom screen, next to a set of visual PowerPoint images, can have greater use in survey architectural history courses, than its seemingly base rudimentary intentions.

Second Course Utilization:

The instruction of the compulsory modern architectural history course, where larger groups of students are assembled in one room, is a mighty difficult arena to expect substantive academic discussion to take place. An on-campus, tiered-seating lecture room containing between 42 and 58 students is not at all conducive to, nor fostering of- casual middle-of-lecture question and answer sessions brought up by individual inquisitive students. After teaching the history of architecture and urban planning history course (compulsory) on campus, the identical class was later fully transferred to an online format. This transition required the complete reconstruction of all PowerPoint slide decks, for they were formerly created with singular letters projected upon an image, where, with the instructor standing in the classroom, the remainder of the word highlighting what was shown in the projected image, could be written on the dry erase board with a felt-tipped marker. Subsequently, students would know this was an important key word or phrase, and replicate the instructor' act of writing on the board, by writing the word and a brief definition into their class notes. Hence, a great degree of knowledge transfer was facilitated through his act of hand-scribing

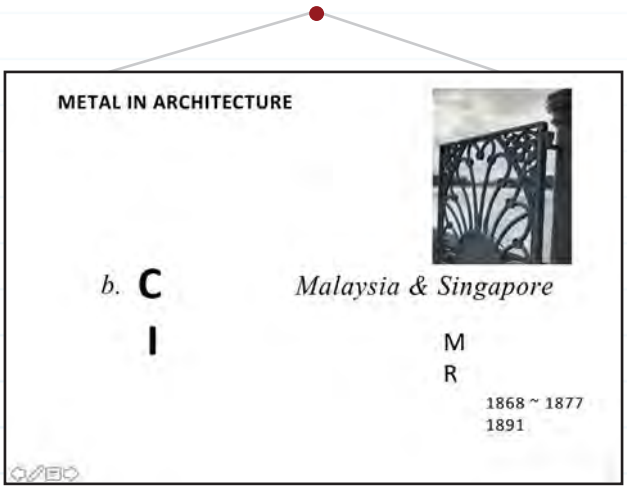

Figure 3: Instructor-presentation PowerPoint slide showing que slide questioning the students to 'fill in the blanks'— whereupon in an on-campus setting the rest of the four words would be written on the dry erase board

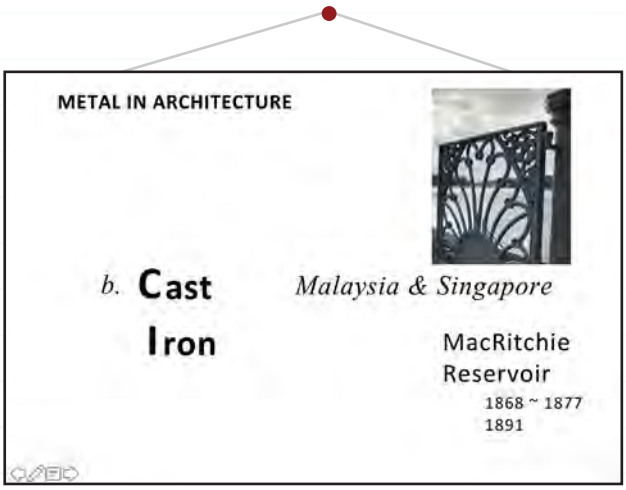

Figure 4: Subsequent image from above, however this version contains 'completed blanks' of four words, filled in, in digital text form, since there is the absence of a dry-erase board in a digital zoom presentation format

In the online format of the class, in order to reduce visual fatigue and increase immediate participation by students, the side chat room was utilized as a digital forum where students were expected to type in possible answers to the suggested key first letter. This process of typing in text to a small side window replicated the act of online messaging, which the students are already used to. The parallel text-chat window soon took on a life of its own in the classroom, whereupon mini-conversations and occasional humorous jests were communicated among the entire cohort of students enrolled in the class since it was a 'public' chat arena specific to the modern history of architectural theory course.

The instructor was able to monitor the online conversations and save the chat room at the end of the instructional time period to assess students' degree of digital in-class participation. The instructor was also able to record who was most attentive and volunteering answers during the class. The course syllabus was pre-configured to include class participation in the Zoom chat room as a portion of the evaluation grading matrix. Hence, students knew ahead of time that their bold act of asking or attempting to answer a question in the chat window was not an academic liability—but instead a zone for rewarding intelligent, well-thought out answers to periodic queries embedded in the PowerPoint slide used during teaching.

Conclusion

This paper has briefly covered the numerous attributes of Zoom software that can be harnessed in the digital classroom to replicate the analog note taking and drawing annotation methods found in traditional architectural design studios. Utilization of the drawing tools, no matter how simplistic they at first appear, will enrich the online class environment and provide the instructor with a lengthy digital record of the quality and quantity of interactions with students in the digital sphere. These images are a record of a student's improvement over the thirteen-week term. Secondarily, the simple Zoom chat-room function can be fully utilized as a relatively risk-free space where students can boldly ask pertinent questions in a digital environment. These acts, tied together, create a new digital architectural and sustainable design learning environment which fully replicates the on-campus, in situ setting. In some specific areas, it even exceeds what can be accomplished in the tangible classroom by ensuring a greater degree of student participation, easier retention of what has been drawn, typed, and reviewed. Lastly, the digital records retained allows the instructor to evaluate each student more accurately. These tools continually merit greater exploration and refinement for the architecture sustainable design program at SUTD.

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DIGITAL RICE: FROM PADDY TO PADLET

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Can you plant rice online? That's what I had to figure out this year as my Rice Cultures class in January Term 2021 went to fully Home Based Learning.

For the past five years, I have taught an undergraduate course entitled 'Rice Cultures: Technology, Society and Environment in Asia' within the HASS Cluster. Through readings in history, anthropology, and political science, the class traces rice agriculture in Asia from domestication of rice (10,000 years ago) to today and examines its impact on culture, forms of political authority, technological design and economic development. I also situate rice farming as a kind of 'model system' for exploring a range of social science theories about the pattern of human-environment interaction, from environmental determinism to cultural ecology, and to improve understanding of the problem of sustainability.

At the core of Rice Cultures pedagogy is a focus on the co-development of the rice plant and human culture. On the one hand, biological features of domesticated rice such as the loss of seed-shattering are a direct consequence of human cultivation—when rice plants began to be harvested for grains, over time this 'unconscious selection' enhanced the reproductive fitness of grains that keep their seeds rather than scattering them. On the other hand, scholars such as historian Francesca Bray have argued that certain biological characteristics of rice—for instance, its very high seed-to-yield ratio, over a hundred times greater than wheat -- have historically enabled a trajectory of technological and economic development that differs in important respects from what she calls the standard 'Western model' of modernization. Since understanding the biology of the rice plant is essential for understanding the sociology of rice cultures, an important part of the course pedagogy is the Rice Planting Lab. At the beginning of the term, I bring in seeds, soil, pots, and gardening tools and the class heads out to SUTD's 'experimental field': the rooftop plot in Building 5 outside of the Fab Lab. In groups, the students mix up the soil with water inside the pots and carefully plant their rice seeds. Then, we wait: although we often take visits to the 'rice paddy' at the end of each class, the students are responsible for watering and maintaining the plants. By the end of the class, most pots are filled with beautiful green rice plants (unfortunately, seed to harvest takes around 120 days, too long for a single semester—though I let students take the plants home at the end). In some years, I designed the planting as an 'experiment', so each group tested out a hypothesis: for example, one group compared different densities of seeding to see which led to the tallest plants; while another tested the effect of playing pop music to the plants. I've always noticed that when we go out to the field, and put our hands in the mud, the dynamic of the class changes, as students share tips and try out new ideas (Figure 1).

Figure 1: Planting rice on Building 5 rooftop

They come away with a totally different relationship to book-based concepts like 'the moral economy of the peasant' or 'agricultural involution' after experiencing what planting rice is like first hand. And the students seem to love the chance to not only read about the history of planting rice, but to plant it themselves: One student wrote in the student evaluations (2016), "I really liked planting the rice as it was one of the most hands-on, interactive, and interesting things that I ever did in HASS." Another wrote: "Great approach to learning rice culture with real life hands on experience!"

As the January 2021 term approached, however, I was concerned: HASS classes were designated for Home-based Learning and I planned to use a combination of Zoom and recorded PowerPoint lectures for teaching. There was no chance we could safely gather as a class (25-50 students) on the roof of Building 5. My first thought was to cancel the Rice Lab. But I began receiving e-mails from students who were considering taking the course, asking whether the Rice Lab would still be taking place, and sounding disappointed when I said that it was cancelled. But, how could we do a "Home-Based" Rice Lab?

When I read a newspaper article about a spike in home gardening during the 2020 Covid 'Circuit Breaker', I had an idea. Why not plant rice at home? When the semester started, I distributed rice seeds, soil, and pots to each student. I then adapted the digital pedagogy tools I was already using to turn 'home gardening' into a collective and collaborative activity: almost as if we were in a digital version of a real rice paddy. First, I recorded short instructional videos where I gave basic lessons on how to plant rice and uploaded these to eDimension. By using videos, I was able to demonstrate techniques much more effectively than I could if I only provided written instructions.

Still, the biggest challenge was not transmitting information from instructor to student, but how to build up community interaction among the students.

To mimic the social collaboration that seems to spontaneously emerge when we typically plant rice in the field, I used Padlet, a real-time collaborative web platform that has been praised for enhancing student collaboration. One of the Padlet modes is an interactive, scrolling blog. I set up the blog for students to post updates on the progress of their plant growth, as well as ask questions or give advice. Although I made participation voluntary, the students really took to it: Padlet makes it easy to post images or even videos using your phone or computer, so the blog quickly filled up with images of seedlings and young plants (Figure 2).

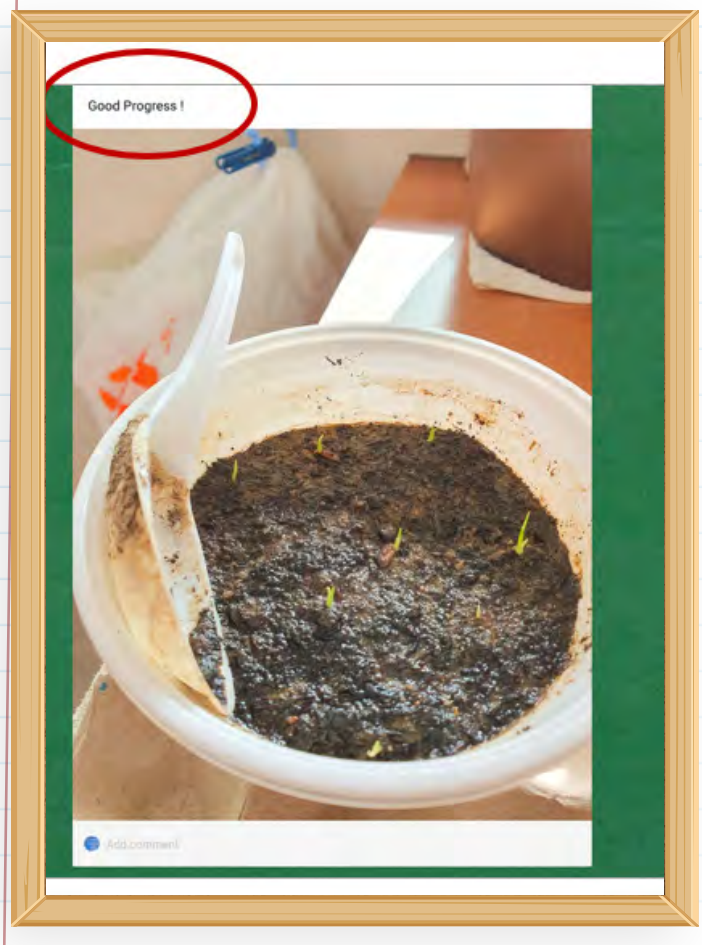

Figure 2: Student post on Padlet

First posting pictures with exclamations like "Little Sprouts!" or "Good Progress" as the seeds took root, the students then began posting speculations of what was going well, or not so well ("Mine grew taller but turning slightly yellow, I think I didn't give it enough water :c"). Finally, by the end of the semester some students were posting photos of "early rice grains" (Figure 3)! I was really impressed that they were almost able to harvest their crop! (Figure 4).

Figure 3: Student post on Padlet

I was glad to see in the "end of term" student evaluations that the Rice Lab was one aspect of the course that students appreciated most, even though we could not use the field on Building 5. One student wrote that they "Love the rice planting aspect that teaches us sustainability of rice planting", while another simply wrote "growing rice!" in response to the question 'what do you like about the course?'. Out of 8 written comments responding to that question, 3 mentioned planting rice as something they liked.

Figure 4: Home-based rice, nearing harvest. Photo and rice planting credit: Tan Le Xuan

Conclusion

The lesson, I think, is that we should not think of digital technology or Home-Based Learning as necessarily opposed to hands-on activity, or even hands-dirty activity. In fact, with new digital and mobile platforms that facilitate sharing of visual, video, and aural media, the notorious challenge of translating skill-based, gestural activities beyond face-to-face situations is being overcome (think of the difference between a recipe in a cookbook and a video demonstration of a chef making the dish). I am hoping I can bring students as a group back to the outdoor experimental field next year. But even if we're in the field, I'll continue using the Padlet blog in parallel with the rice planting, allowing me to extend collaboration and communication beyond scheduled class meetings, and bringing a bit of the feel of the rice paddy online.

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THE EFFECTIVENESS OF AN ONLINE QUESTION GENERATING SYSTEM (CEREBRY) IN 10.018 MODELLING SPACE AND SYSTEMS

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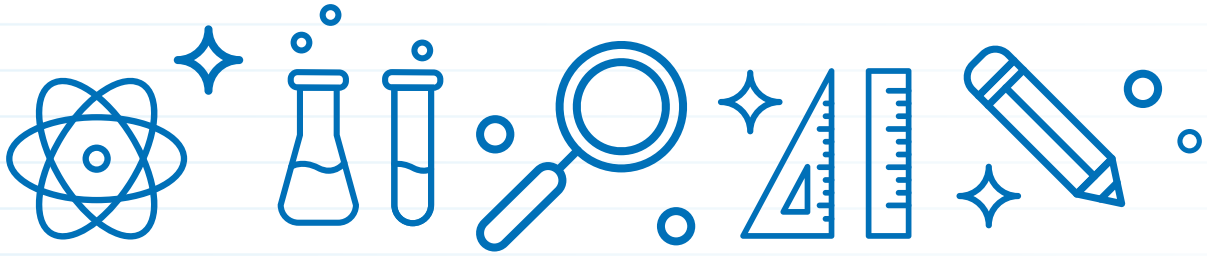


Studies have shown [1,2] that students are not able to effectively recall information by just reading the material or lecture notes. George Polya's famous remark: Mathematics is not a spectator sport, is not surprising, given that studies [3,4] have shown that students learn more effectively by doing homework, rather than just reading notes or learning from online videos.

In Singapore University of Technology and Design (SUTD), students are assigned traditional pen and paper homework for the Freshmore mathematics curriculum. However, there are the texts of our homework questions from 10.004 Advanced Mathematics II, 10.007 Modelling the Systems World on Chegg, e.g [5-9].

While there is the argument that students who use these online platforms to get answers directly hinder their own learning process, instructors are sometimes asked to give "remedial" workshops during the Independent Activity Period (IAP) to help these students (without teaching loads).

Having personalized, adaptive homework assignments mitigate or offer better remedies for the above problem, as each student would get a question tailored to her/his abilities. Students are able to practice on questions at their level, rather than copying homework and not ending up understanding the concepts. These homework assignments allow students to make errors without fear of penalty, until they reach a certain level of understanding. Research has also shown that making these errors does not impact students' eventual understanding [10-11] and having such personalized homework assignments gives students a "safe space" to make mistakes without being penalized for them.

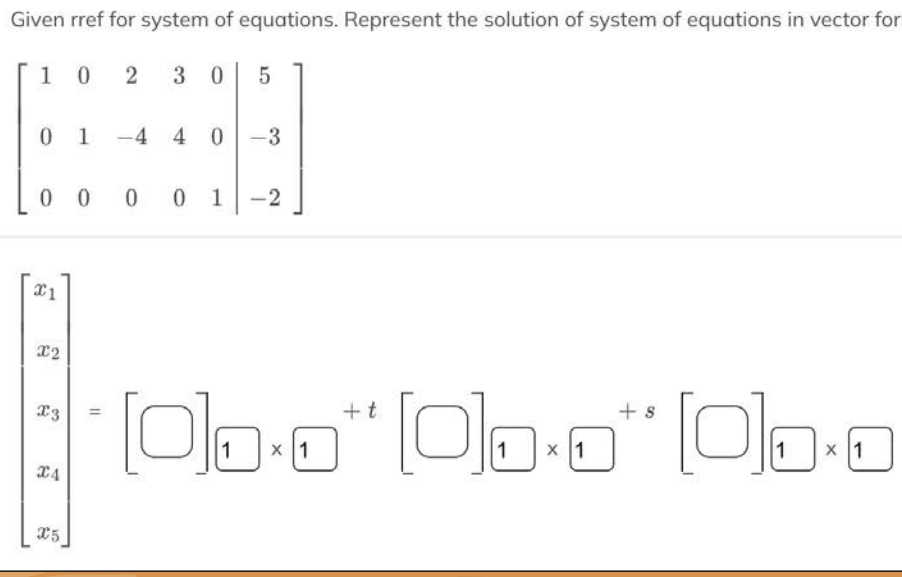
Since 2019, Cerebry, an online question generating system, has been used for homework in some SUTD math classes, such as 10.001 Advanced Mathematics I, 10.004 Advanced Mathematics II, and now, 10.018 Modelling Space and Systems.

Cerebry works the following way in these math classes: Each week, instructors would collaborate with Cerebry's back-end developers to create specific question templates for a specific topic. The Cerebry engine would then generate questions based on these topics for students to do as practice. These topics are assigned as a small proportion of the homework grade, and students would have to reach a certain level of understanding (number of topics practiced correctly) to get the grade.

In 2019, Sergey Kushnarev, Keegan Kang, and Shubham Goyal conducted a study [12] to assess if there was an improvement in students' performance in multivariable calculus, and there was evidence to show that there was, since students who practiced more questions on Cerebry had a better performance in the final exam. However, there were some limitations to this research. For example, the study could not claim causality, i.e. practicing on Cerebry was the direct cause for students to have better grades. It could have been the case that students who are naturally hard working or doing well in multivariable calculus would engage more with Cerebry, and hence get a higher final exam grade.

In 10.018 Modelling Space and Systems, the task was to further refine the study done in 2019 to assess if Cerebry improved students' understanding of linear algebra. Linear algebra covers both computational topics (Gauss Jordan algorithm, computing determinants and inverses of matrices) and abstract topics (understanding if a set of vectors is linearly independent, span a subspace, is a basis of a subspace, eigenvalues and eigenvectors). Questions were hence set on Cerebry corresponding to both computational and abstract topics, and students were evaluated on how they performed on the homework, as well as the exam questions. Students would have to practice on Cerebry each week, before starting on their homework.

The below image shows an example of a question in Cerebry.



For several types of questions given to students on Cerebry to practice, there was also:

1. An extended version of these questions given in written homework
2. An (almost) identical version of these questions given in the exam
3. Questions testing the same concept given in the exam, but stated differently; the goal is to evaluate how students performed on these questions.

A more detailed version for items 2-3 is written for a conference presentation (IEEE TALE 2021) and I would like to take the opportunity to share the results for item 1 in this article.

The extended version of these questions were given in the form of a "story", but students would have to apply the exact same computations tested in Cerebry. Here is an example.

On Cerebry, students would have been asked to determine the span of a set of vectors, or determine if the span of two sets are equal (or unequal). However, an extended version of the question in the homework would be of the following form: Suppose you are solving a system of equations of Cerebry, and are asked to write down the general solution for the system of equations. Cerebry has a model answer in terms of $\mathbf{s} + a\mathbf{v}_1 + b\mathbf{v}_2$. However, as there are infinitely many possible ways to describe the general solution for the system of equations, there is no guarantee that the input of your answer matches Cerebry's right answer. How can the developers behind Cerebry ensure that your answer would be graded correctly?

This question tests exactly the same concepts asked in Cerebry: Are the span of two sets the same (or different)? - albeit instead of doing some computations, students would have to intuitively understand the concept of span.

Another question type asked on Cerebry: Students were tasked to multiply two matrices which were sparse (had lots of zeroes) and had to quickly identify the non-zero terms, which was perfectly doable by students. On the other hand, there was a homework question which tasked students to change the term: $AB^{-1}C$ to some $AD^{-1}C$, where D was a diagonal matrix to improve the speed of computations, and there were many students who did not see that $AD^{-1}C$ was a much faster computation.

Unfortunately, results borne out by students' feedback forms as well as interviews with specific students have shown that Cerebry has not achieved what we (or technically the author of this article) wanted, i.e. understanding of a topic, but rather instead achieved better computation in an exam.

For example, the following feedback was received (paraphrased slightly)

1. Half the homework questions were too difficult / too long, and students preferred shorter questions (note these difficult questions required students to understand a concept, rather than do calculations)
2. Instructors should not set a PhD level question in the course (I alluded that the developers of Cerebry were PhD graduates and this was the type of problem they were facing in their software)
3. Homework should be more of Cerebry type of questions, rather than long form questions

and during the interviews with randomly selected students, I found that there was a clear distinction between students who

1. genuinely put in effort to understand the topic
2. "rushed" Cerebry just to get the grade for the week, and not care about understanding

Generally, it looks like there was a sufficient proportion of students who did Cerebry just to tick something off a checkbox - something else they needed to do to get a good grade in Modelling Space and Systems and move on. While they performed better (computational wise) due to practice, they did not see why they were doing the computations.

I also set one question in the exam: Describe a practical scenario where using an eigenbasis is favoured over other bases. This was covered in the lecture notes, (indirectly covered in) homework assignments and cohort activities, as well as in Technological World. When I asked this question, I remember the instructors telling me it would be difficult to grade (e.g., should a student who writes half a page get the same marks as someone who wrote a few sentences?). Unfortunately, their concerns did not come to light. I give the breakdown of the students who made any attempt here, regardless of length.

Example from Physics: 31
Example from notes / homework / cohort activities: 28
Other example: 31 | Blank: 388

Conclusion

At this stage, I believe we have to ask ourselves as educators what we truly want. Do we want students to perform well on exams, or to understand topics? No doubt as educators, we would want to use technology to help our students do better and learn, and there is evidence that such technology helps our most motivated students. On the other hand, our weaker students (or less motivated students) would not benefit as much. They could theoretically answer more questions correctly in the final exam if they do such targeted practices. However, whether they understand the concepts is another matter entirely.

In conclusion, Cerebry is great for getting students to do well on computations. However, perhaps not so much, when it comes to understanding concepts. As SUTD is moving towards a cyber-physical campus, and employing tech tools in getting students to learn, it might be wise for educators to draw a distinction between tech tools that: help students perform computations better, and tech tools which only work if students using them have sufficient motivation to improve.

Disclaimer

The opinions here are of those of the author and do not necessarily reflect those of the math teaching team.

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CASE STUDY OF AN ONLINE GRADING TOOL: GRADESCOPE

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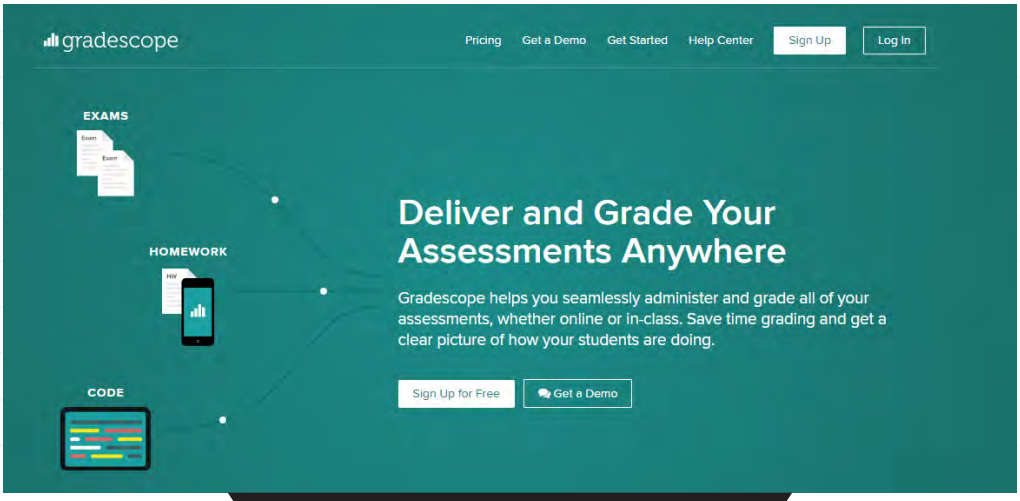


https://www.gradescope.com/

What is Gradescope?

Gradscope [1] is an online grading tool that helps instructors to seamlessly grade and administer students' homework assignments and exams, whether online or in-class. It also serves as a homework submission platform that allows students to submit their digitized homework. The main advantage of this system is the consistent way of grading with pre-set dynamic rubrics. The flexibility of dynamic rubrics allows instructors to edit grading rubrics at any point in time while allowing for all previously marked homework to be updated automatically if required. It not only saves time for instructors' grading, but also provides a clear picture of how students are doing for each homework assignment. Gradescope was first launched in 2014, then purchased by the US company, Turnitin, LCC in 2018.

My Prior Online Grading Experience

I teach a Freshmore Physics course. Due to the Covid-19 pandemic, we had to minimise physical contact with students, even though some extent of physical classes were allowed. I felt that an online homework submission system would be a good solution since there would be no physical meetings or logistics needed for online homework submission and it also helped to digitise the homework for future referral. Thus, I was motivated to explore and try out new tools that could help in my teaching.

eDimension, the current learning management system (LMS) provided by Blackboard, does have an online homework assignment submission feature and allows instructors to grade through the system. I had tried out this feature earlier, back in 2017. Unfortunately, I found that the feature had limited functionality, not very convenient to use, and with a monotonous interface. At that time, annotating a PDF document on a web browser was not intuitive. The writing experience was not as natural. Furthermore, Blackboard did not support bulk upload of graded homework to individual students if I wanted to grade offline by downloading students' assignments. In fact, it was a counterproductive experience, as I had to spend more time in grading and dealing with the system. I stopped using the grading feature in eDimension since then.

Even though I had been aware of Gradescope since 2017, I only started using Gradescope in one of the Freshmore cohorts, as a trial run, in September 2020 for Term 1 subject, 10.015 Physical World. I implemented this again in three other cohorts that I was in charge of in January 2021 for Term 2 10.017 Technological World, as the second trial run.

Why Gradescope?

At the first glance, Gradescope provides rubric-based grading. Instructors pre-set the rubrics and only need to apply those rubrics accordingly while grading (see Figure 1 as an example). Multiple rubrics can be applied if students have more than one error. Also, instructors could setup new rubrics and modify existing rubrics at any point in time, even while marking. The total points are auto-computed. This is very convenient, time saving and minimizes human error in calculation. In addition, this is an efficient way of marking since instructors can apply the same and consistent rubrics throughout the whole cohort. These rubrics can be revealed to students as feedback and explanation when they receive graded homework. Text and doodle annotation are also possible. Instructors can also leave specific comments and feedback to individual students if necessary.

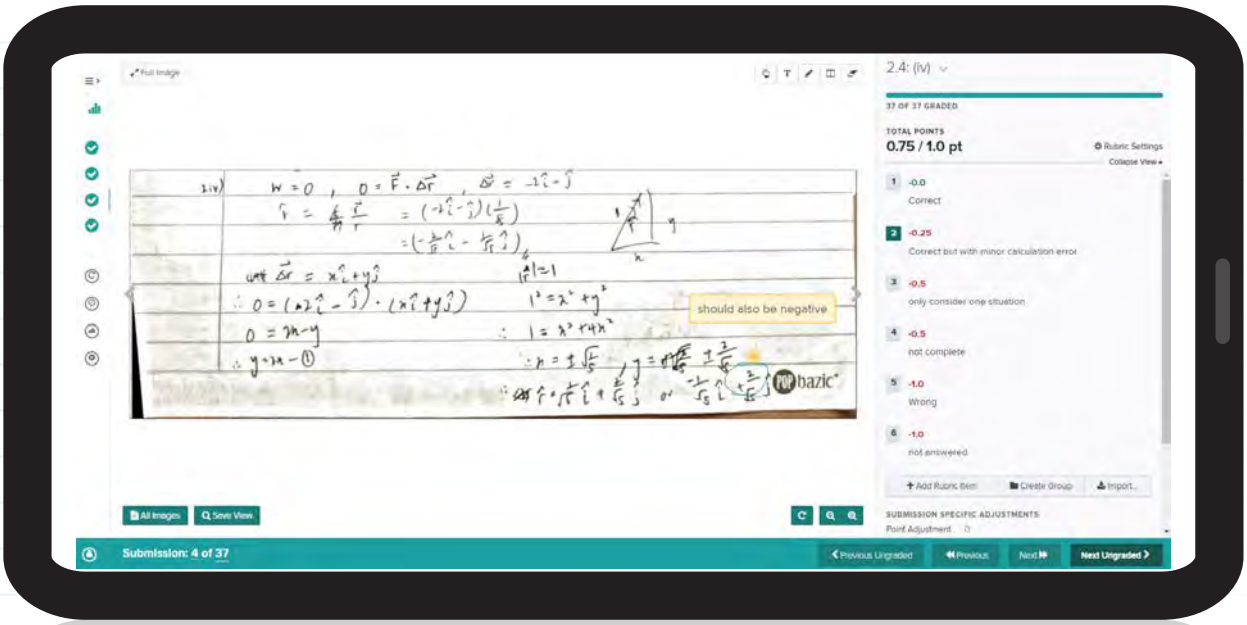
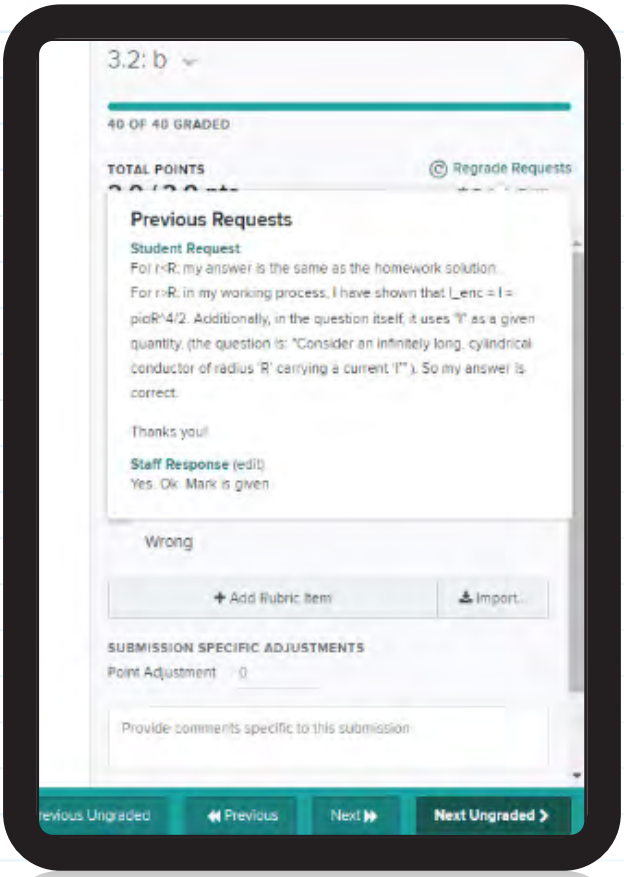


Figure 1: Dynamic rubrics with appropriate mark allocation can be pre-set and modified accordingly (highlighted in the red box)



There is also a regrade request feature, which students can trigger for any appeal, as shown in Figure 2. Every submission, grading and action are logged in the system, and thus it is transparent, fair, organized and efficient. The system and workflow decrease instructor's time in grading while maintaining the quality of grading and teaching.

Figure 2: Student request for regrade. Instructor can respond accordingly

Instructors are also able to glance through the progress of each homework from the instructor dashboard in real time. As shown in Figure 3, the information includes homework due date, number of submission, progress of grading and even any regrade request from students. At the end of the term, instructors can download students' homework grade into Excel spreadsheet for further populating of students' grade. This means no more manual keying-in of students' marks! Students also have a similar dashboard that indicates each homework due date, their submission and the received grade for each homework.

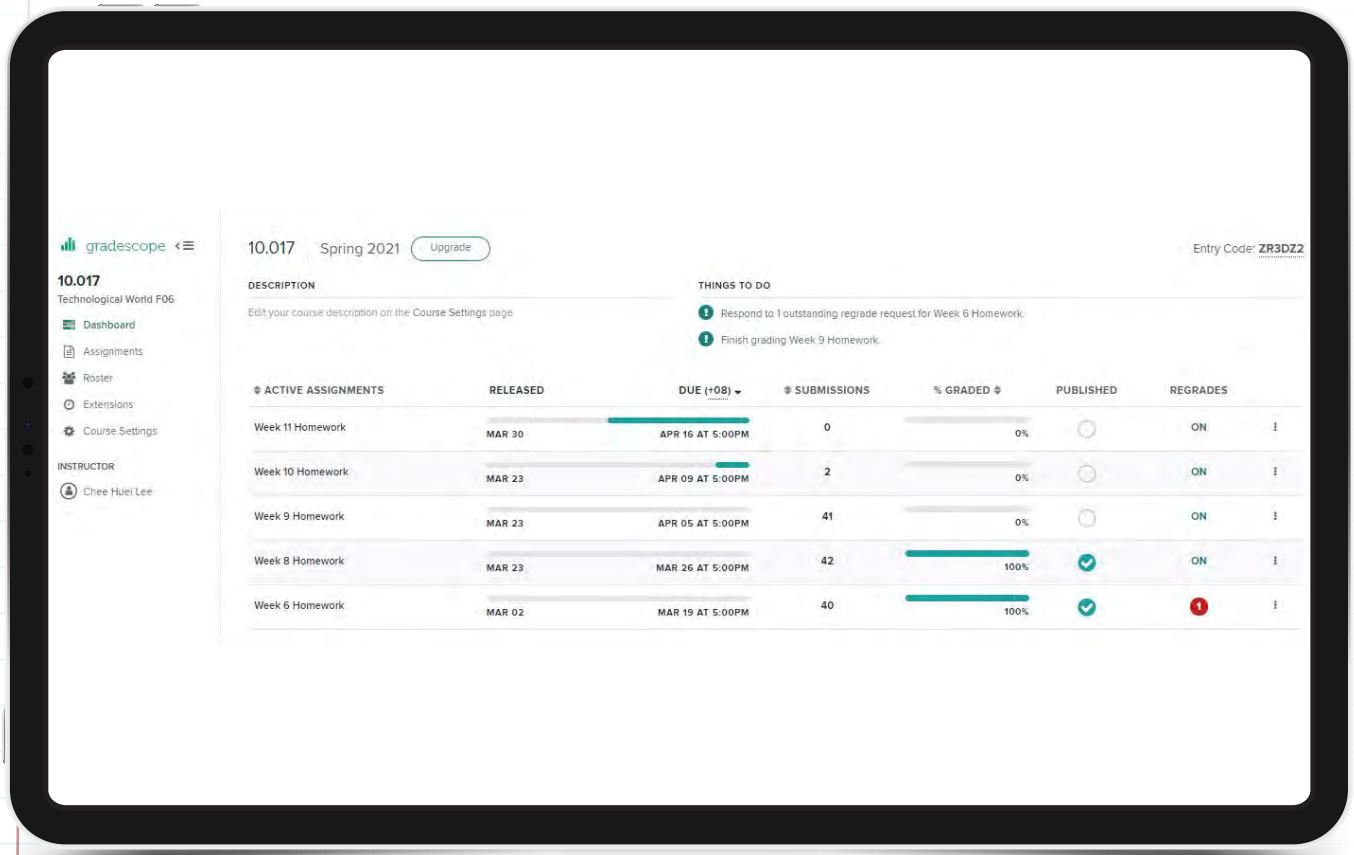


Figure 3: Instructor dashboard that presents an overview of every assignment, including number of submission, grading progress and regrade request

Advantages and Disadvantages

I think one of the biggest advantages of Gradescope is the dynamic rubric setting. Instructors can add in more rubrics while grading. The existing rubrics can even be modified and the change will be immediately applied to all previous graded papers. It happened to me that I needed to redistribute the homework marks based on a new marking scheme. It was just a couple of clicks to update the rubrics and voila! Gradescope saved me a lot of trouble regrading or recalculating students' marks.

Another advantage is that there is no limitation on the number of students in a course, but it depends on the type of subscription. The pricing varies from USD1 to USD5 per student per course, depending on the features and the subscription plans. There is also an institutional subscription package for LMS integration and advanced analytics.

Advantages usually come with a price. While the platform brings great advantages, it introduces a new workflow to students and instructors. Firstly, as my personal practice, I would spend ~15mins in class to explain the new system and workflow to students. A written instruction was also provided on how to upload homework to Gradescope. In addition, I ensured that all students possessed necessary device (a smartphone with camera and Internet connection) to avoid any disadvantage to certain group of students. Fortunately, it had not been an issue. I encouraged students to try out the system but also allowed them to opt out. They were free to submit physically hard copy if they wanted to. As of now, all students in my class used Gradescope to submit homework and received graded homework.

From students' perspective, there is an additional workflow besides completion of homework on paper as per normal. For submitting homework, students are required to take a clear picture of their hardcopy homework using their smartphone (it is the most convenient way, instead of scanning them by a scanner). Converting to PDF format is optional as Gradescope accepts both jpeg and PDF format of documents. Upon uploading, students have to assign the appropriate page to the associated question number so that Gradescope can prompt the correct page to instructors when grading that specific question. It streamlines the grading process without spending too much time searching for questions and answers in multiple pages. Students are able to submit their homework anytime, anywhere with their smartphone as long there is an Internet connection. No app needs to be installed. They are able to resubmit or update their homework as many times as they want before the due date.

For instructors to use Gradescope, a student list needs to be created based on students' email. It can be easily imported from an Excel spreadsheet template. An assignment outline and allocated points are to be set up in Gradescope (see Figure 4 as an example), prior to launching out for submission. This outline is for students to assign their homework page accordingly when they do the submission, as mentioned previously. Instructors have to set up the rubrics and grade based on this outline too. There may be a slight learning curve for instructors to familiarize with the system, but overall it was quite straightforward and intuitive.

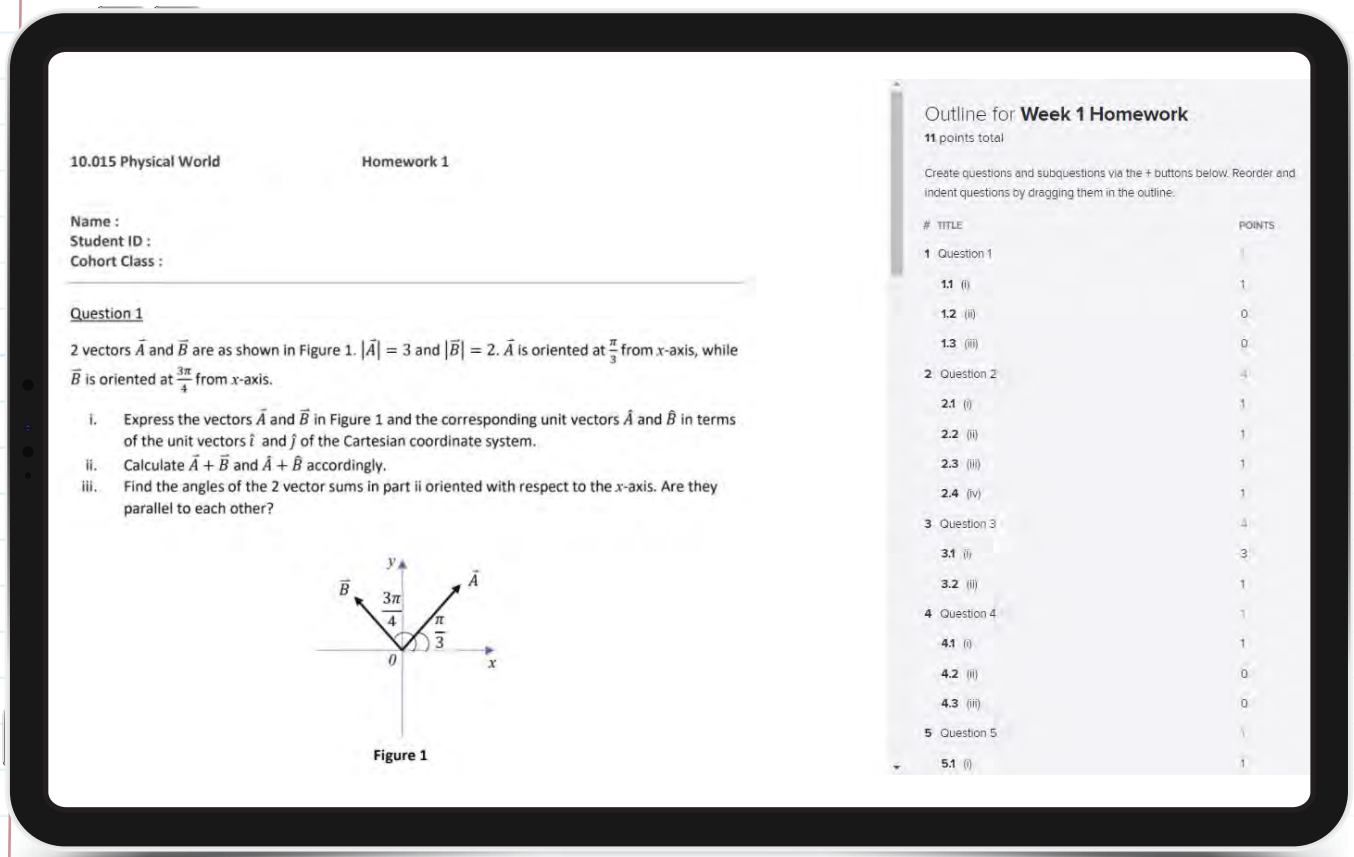


Figure 4: Instructor needs to set up a homework outline in Gradescope

Concluding Remarks

Several students provided feedback that Gradescope was convenient and easy to use. So far, from my experience, there was no major complaint about the additional workflow from students or to opt out of this tool to turn in physical copies of homework.

Similar to other educational technologies, such as Zoom and MS Team that we have used in response to online teaching and learning due to Covid 19 pandemic, the deployment of Gradescope is growing drastically and has become popular across many higher educational institutions around the world. There are also many tutorials available sharing how Gradescope is useful for homework or exam grading [2-7].

In addition, digital writing tools and tablets have become very common amongst the teaching faculty and student community. Thanks to technological advancement and affordability, the writing experience using digital devices is getting as natural as writing on paper with a pen. Students not only embrace the technology for note taking, but they use it to complete their homework assignment paperless. Riding on this trend, online homework submission will become even more seamless in students' daily routine and instructors' workflow.

Gradescope has AI features to cater the needs for exam grading. An additional workflow is needed to scan students' answer scripts, but it can be uploaded in bulk. With the image recognition algorithm, the system can recognize hand-written names and ID, then populate the answer script into an individual student's profile. Exam scripts can also be graded simultaneously by multiple instructors in team teaching. This tool for grading is not subject specific, as far as the rubric-based grading is concerned. Thus, it can be applied to sciences, mathematics and engineering subjects. Written essay grading tends to be subjective, so the effectiveness may vary, depending on the use-case. It is also able to run code auto-graders for coding/programming assignments, but this feature is still under active development. Further documentation can be found in the reference [8].

Gradescope is ready to be integrated with various major LMS to provide seamless teaching and learning experience, but it requires an institution licence.

In summary, instructors can gain advantages from this new workflow of grading in Gradescope, which include (but not limited to):

- A dynamic rubric-based grading which is transparent and is a very consistent way of grading, compared to conventional way of grading.
- The grading process is highly efficient which significantly reduces the instructor's grading time.
- It avoids the logistics of homework submission and return, therefore reducing inter-personal contact and hassle of homework missing.
- It minimises human error in calculating and populating students' marks.
- It is a convenient way for students to submit homework assignments anytime, anywhere. Students can receive prompt feedback from instructors.

While I personally have found Gradescope to be useful in my teaching, I think that we could create more use cases among instructors and students at SUTD before moving to institutional LSM integration. So, I would like to invite other colleagues to consider and evaluate if Gradescope may be useful for them in their courses. Gradescope can be used for any subject.

Disclaimer

Chee Huei has a free Gradescope instructor account with basic features, given by Gradescope as one of the five first users from SUTD.

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TEACHING TIPS ON BLENDED LEARNING

KATE QI ZHOU, ENGINEERING PRODUCT DEVELOPMENT (EPD - Graduate Student and GTA)

Active learning is referring to students being actively involved in the learning process and thinking about what they are doing [1]. The outbreak of Covid-19 has changed the way of conducting teaching but the importance of active learning remains the same. Lecturers are hurried to search for new teaching techniques and methods that are suitable for online learning to teach the same content.

As a lecturer for adult learning before starting my graduate studies at SUTD in September 2020, I was used to conducting my classes in the traditional, face-to-face class format. However, the onset of the pandemic in my first term of graduate studies meant that all my lessons were conducted online. Coming to Term 2, I enrolled in a unique course called “Teaching at SUTD: Engaging the learners”, which introduced basic foundations of teaching, especially in the online learning environment, and it provided graduate teaching assistants (GTA) like myself a valuable opportunity to observe experienced teachers.

It was a special experience for me as it offered me an opportunity to rethink teaching, by combining the perspectives from both students’ and teacher’s viewpoints. The critical elements of teaching are the same, namely learning. However, the relationship between teachers and students, the delivery of content, collaborative learning, and self-directed learning are managed differently. Below are some tips to help lecturers adapt to online teaching.

A. Lecturer and Student Connection:

The relationship between lecturers and students plays a positive role towards the students' learning outcome [2][3]. Compared with the physical classroom, where it is easier for lecturers to interact with students through facial expression, body language and influence students by their personality, online education has some disadvantages such as a lack of emotional communication and ineffectiveness in supervision [4]. Lecturers need to connect with students in the new form of a relationship built through a virtual interface. This is not only to help students to focus on the learning material but also the soft aspects of learning, including learning attitudes and learning habits acquired from the lecturer. Tips for forming a close relationship between the lecturer and students:

- Arrange the first lesson to be conducted in the physical classroom if it is feasible.
- Share personal profiles like a hobby, daily life photos, personal experiments, etc. to bridge the gap with the students.
- Use an internet breakout room to allocate students into small groups, the lecturer joins the discussion to interact with students in small scale.
- Design mini feedback forms in short intervals to gather students' input on their learning status so that the lecturer can adjust along the way.

B. Lecture Content delivery:

The first key element of content delivery is the teaching material. In online learning, the material is shared on screen. There are two ways to prepare for this. According to one of them, the material has been written down in the PowerPoint slides, which the lecturer can refer to during the lesson, which mass information needs to be gathered beforehand. Another way is walking through the step-by-step process in front of the students. This is suitable for walking through math, physics problem solving or experiment that need to show the students how to arrive at the final result. To achieve the best online demonstration, screen sharing using a handwriting device like a tablet with a digital stylus will be more convenient than the computer. Another option is to set up a camera to face the paper to be written on or an experiment that needs to be demonstrated where lecturers can explain the experiment.

Another key element of content delivery is student feedback on the teaching material. During offline class, where the lecturer and students are face-to-face, students respond to the lecturer's question by raising hands and raising questions when needed. Even if the students are not answering any questions directly, facial and body expressions can signal whether the students are following or not. However, even when students turn their cameras on during online lessons, their facial expressions are hard to catch. Hence, software tools will be needed to supplement and facilitate the teaching process.

Zoom polls can be used to gather students' feedback, acquire their understanding and give peer assessments. Google docs can be used as a central record document to record students' ideas on the spot (like the whiteboard in the classroom). Mentimeter can set up live polls, quizzes, word clouds, Q&As to get real-time input. Tips on class material preparation:

- Gather information needed and put it into one place (PowerPoint or a folder) for easy access.
- Share tools like tablets and digital stylus, making sure that they are set up correctly. Extra camera to be set up to live stream the experiment process if needed.
- Prepare polls, quizzes, etc. in an online tool to evaluate students' understanding before the class and be familiar with them.

C. Collaboration Among Peers:

Collaborative learning means to let two or more students work together for a common goal [5]. It can be a project, an assignment or a research task, etc. It is essential to encourage students to learn from each other by sharing their unique backgrounds and knowledge. It cultivates students' teamwork spirit and maximizes their learning by acquiring information from peers.

During my online class observation for a course on "Teaching at SUTD", online tools were used to facilitate the process even though students were not in the same place physically. Students were assigned to the different groups beforehand, and projects were given. After that, they were allocated to separate breakout rooms to start the discussion. At the same time, Google docs are used to document what they have discussed and the questions that were still in doubt about. The professor joined the discussion in the breakroom separately, answered their questions, and inspired them to draw conclusions. After that, the students worked out the project details offline and submitted a presentation of the findings.

However, there can be several challenges in making a group project run smoothly for online classes such as the one above. First of all, if the class is online from day one and students have never met each other face-to-face, social bonding is limited. To them, the other classmates are no more than an "icon" displayed in Zoom class. It is not feasible to let the students form the project groups by themselves spontaneously. Furthermore, students would tend to pick the group members from similar cultures based on their names, which is not suitable for the diversity of the project outcome. Secondly, ensuring group projects are going on track and meeting the initial goal represent a basic issue regardless of the mode of the classes. It is then essential to get students to frequently update on the project status and to review promptly. Tips on facilitating group projects for online class:

- Assign students to different groups if the students are new to each other, identify a "project manager" to drive the project if needed.
- Create a discussion room to allow students to communicate with each other in class.
- Lecturers join in the discussion during class time to answer students' questions about the project.
- Break the project into multiple minor assignments or different milestones to facilitate the project on track.
- Promote students to use online shared space (like Google docs, Microsoft words, etc.) to document their discussion and presentation.

D. Self-directed Learning:

One of the common ways to benchmark a student's learning outcome is through mini quizzes and exams. However, it is good to focus on how lecturers can help to foster independent study habits and self-directed learning. A proactive learner who takes the initiative to learn would learn more and better than the passive learner [6]. In this perspective, the lecturer plays the role of a facilitator to help the student form the habit that would benefit them for their whole life. Online learning, in a way, provides positive support to self-directed learning as students are 'isolated' from others by the screen and mass information from the internet is just one fingertip distance. However, for those passive learners, lecturers need to help them evolve to be active learners. Tips on promoting self-directed learning:

- Design and record asynchronous lectures as a supplementary material to online class to let students learn at their own pace.
- Assign individual open-ended assignments to allow the students to work at their own pace and formulate their answers.
- Set up a shared place as a showcase for students to share their finding.
- Reward the finding to encourage students' effort.

With the continuous wide spreading of the Covid-19 virus and technological development, online teaching has become part of our teaching journey. As lecturers, we need to keep on learning to adapt to the changes and develop our skills to maximize the teaching and learning outcomes

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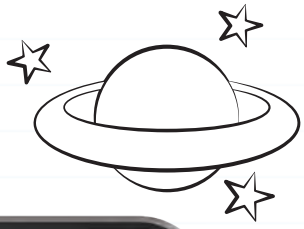
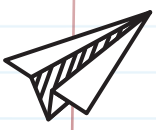
REFLECTIONS ON DEISGN EDUCATION

REFLECTIONS ON DESIGN EDUCATION





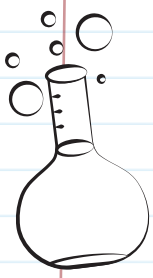
The SUTD call for stories on Design Education was launched in 2020 by Professor Lucienne Blessing and Dr. Sumbul Khan. The call invited the SUTD community to share and celebrate their stories about design education. It welcomed all design related stories, be it successes or challenges, ongoing initiatives, or specific projects in response to the COVID-19 pandemic. Sixteen entries covering a wide range of topics such as using design to solve global challenges, instructional design of serious games, and designing engaging learning experiences were received. The stories were evaluated by four SUTD experts in design education. In the winning entries,

The stories were evaluated by four experts in design education, including one from Learning Sciences Lab. In the winning entries,

- Professors Arlindo Silva and Christine Yogiaman discuss challenges and solutions in multi-disciplinary design education at SUTD.
- Students Vanessa Chia, Justin Yap, Hoon Hoon Chan, Lian Hong Peh and Lecturer Franklin Anariba describe how SUTD students are mentoring younger students in schools to encourage innovation.
- Senior Lecturer Daniel Whittaker discusses how technological tools assisted four ASD students in completing a design project without meeting face to face on campus

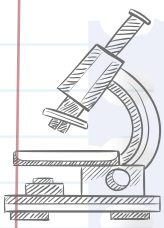
We want to congratulate the winners and present you their stories. As you will see, the stories represent three characteristics of our unique Design Education: multidisciplinarity, collaboration to foster innovation, and harnessing the power of technology to reimagine design education. Taken together, they demonstrate how our faculty and students are pushing the boundaries of Design Education.

For queries/suggestions/collaborations on the “SUTD call for stories on Design Education”, please contact Dr. Sumbul Khan: sumbul_khan@sutd.edu.sg.



THE 2D PROJECT IN TERM 2 @SUTD: A MULTIDISCIPLINARY PROJECT ACROSS MATHEMATICS, PHYSICS, HUMANITIES, SOCIAL SCIENCE AND DESIGN

ASSOCIATE PROFESSOR ARLINDO SILVA (EPD) &
ASSISTANT PROFESSOR CHRISTINE YOGIAMAN (ASD)

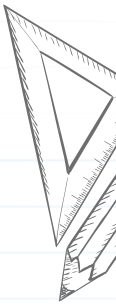


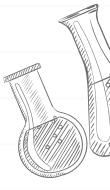
Teaching design in the foundational years of engineering and architecture education has been growing in popularity in recent years, posing some difficulties along the way. This story analyses these perceived difficulties and presents a case of design teaching in which mathematics, physics, humanities and social sciences explicitly come together in a design project at the freshmore level. The experience of setting up this project and assessing the outcome is described, from the perspective of the mathematics, physics, humanities, social science, engineering and architecture instructors involved. Students take four required subjects out of the following five: Theorizing Society, the Self and Culture (TSSC) or World Texts and Interpretations (WTI), Introduction to design (ID), Advanced Mathematics II (M2), and Physics II (P2). Of the four subjects, they choose two to pair with their design project under ID.

Historically, the bridging of subjects has been mostly left for students to figure out by themselves. The 2D project in term 2 at SUTD has tried to tackle this, by explicitly instructing the students to bridge this gap between subjects. Students are explicitly asked, in the context of their own design project, to show how mathematics, physics, humanities, and social sciences have influenced their projects or conversely, how their project has helped them understand in more depth those subjects.

Developing a rubric for multidisciplinary assessment of the 2D project

A project with this breadth is quite difficult to assess and grade. The rubric must work across M2, P2, TSSC and WTI, because the two topics that each individual team will choose to develop during their design project are not known at the start. Therefore, the rubric has to lend itself to interpretations that make sense in each of the subjects. The team that steers the 2D project and the rubric is composed of a 2D project lead coming from the ID faculty team and a 2D lead from each of the other subjects. This team comes up with a top-level rubric (see Figure 1) that is then further detailed if needed for each of the specific 2D subjects (see Figures 2 and 3 for the P2 and M2 detailed rubrics, respectively). This top-level rubric contains four main topics: information, insightfulness, creativity and clarity. The students are made aware of the rubric in week 1, and they know that each subject instructor for the subjects they choose will look at their 2D project poster (this is deliverable for the 2D project) together with their design poster and grade it independently.





		0-1 points	2 points	3 points	Score
	Informed	Not much was done besides "Wikipedia" stuff. Unsurprising or inaccurate.	2D component done honestly but made up of casual references and common-place statements.	2D component is documented in a way that conveys the team's research and expertise in the subject, with references as appropriate.	
	Insightful	No discussion is done on/of the subject. Facts are stated without a critical view, or a justification	Some reasoning is conveyed but not extensively.	2D component discusses conveniently the way in which the subject contributed to a better understanding of the 3.007 project, or even how it transformed/reoriented the team's initial perspective. The reverse can also be true: how did the 3.007 project help in cementing the knowledge acquired in the subject by providing a proving ground on which to apply the team's previously acquired knowledge.	
	Creative (presentation)	The presentation of the work is done in a very boring or unsurprising way.	Good poster design but poor content, or good content with a poor design of the poster.	2D component should present the knowledge from the other modules in a creative (but logically sound and/or persuasive) way.	
	Clear	Subject not clearly presented. Topics seem to be unrelated to the 3.007 design project.	Links are shown but not in an immediately perceivable way. Links seem to be "around the topic" but not straight to the point.	2D component clearly expresses the links to the team's project – a specific type of philosophy, concept or method of interpretation. It is concise in its reasoning.	
				Total score (0-12)	

Figure 1: Top-level rubric for the 2D project. This was also the rubric that TSSC and WTI used

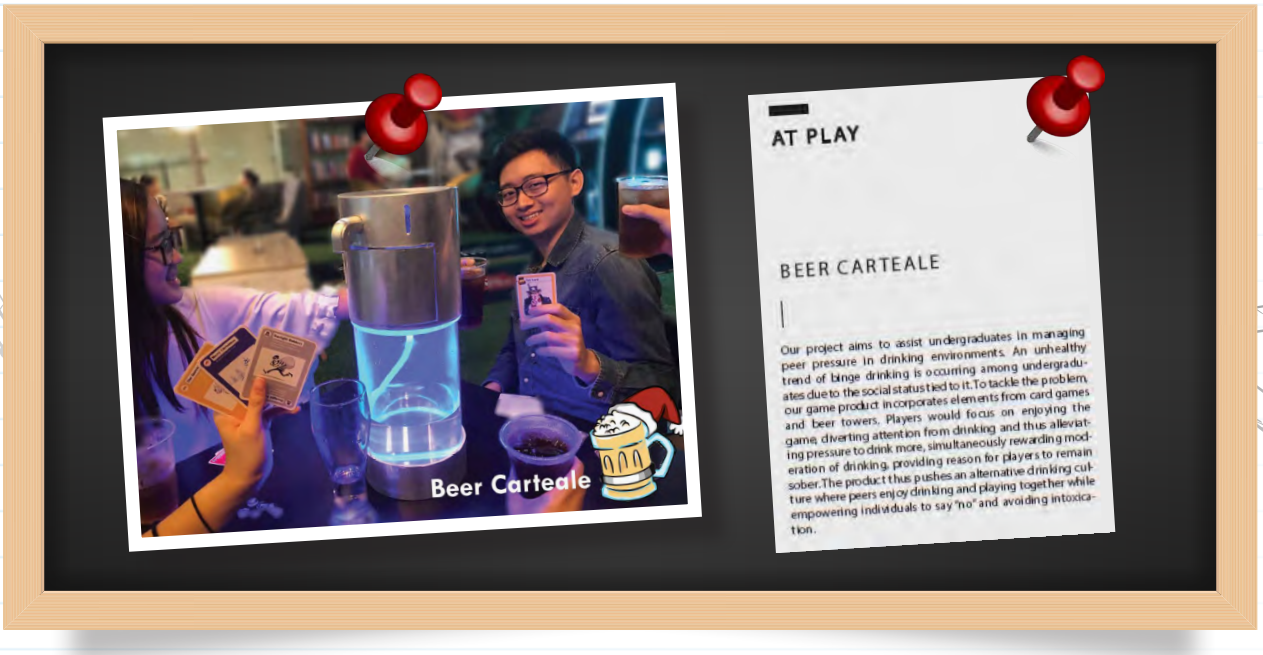
		0-1 points	2 points	3 points	Score
	Informed	Poorly defined problem statement, Inaccurate/ incorrect implementation of physics knowledge in the prototype and problem statement.	Unclear problem statement, minor mistakes found in the physics concept and implementation.	Identify appropriate physical concepts and principles, and clear problem statement. A brief summary of research with proper referencing.	
	Insightful	Significant errors found in measurement/ analysis. Conclusion does not make sense.	Minor errors found in the measurement/ analysis.	Conducting proper experiment based on their prototype to analyze/ characterize your prototype, investigate its specifications, limitation, etc. Correct measurement, analysis and draw a rightful conclusion. How conclusion helps students to make decision during design process.	
	Creative (implementation)	No improvement/ worse ways of solution/implementation.	Conventional ways of solving problems/ insignificant differences from conventional solution.	Significant differences from conventional ways of doing things/ solving similar types of problems. Showing improvement compared to conventional solutions.	
	Clear (presentation)	Hard to read and understand.	The poster is understandable.	The poster is presented in a precise and concise manner. Easy to read and understand. Physics component is clearly linked to the team's project.	
				Total score (0-12)	

Figure 2: Detailed rubric for P2

	0-1 points	2 points	3 points	Score
Informed (DEFINE THE MODELING PROBLEM)	(1pt) Problem statement is difficult to understand or is buried in the text. (0pts) No problem statement is given.	Problem statement is easily identifiable but not precise or consistent with other statements in the poster.	Concise problem statement that indicate exactly what the output of the model wi	
Insightful (ASSUMPTIONS, LIMITATIONS, VARIABLES)	(1pt) Assumptions and justification exist, but are difficult to identify in the text. Variables/parameters are either barely mentioned or hard for the reader to identify in the text. (0pts) No assumptions, no variables or parameters are identified.	Primary assumptions are noted; justification or readability is lacking. Important parameters and variables are listed properly but without sufficient explanation.	Primary assumptions used to develop the model are clearly identified, easy-to-read and well justified. Limitations due to simplification are stated when appropriate. Notes and rationalizes the need for the primary factors that influence the phenomena being modeled in a readable format; proper units are specified.	
Creative (SOLUTION)	(1pt) Model is stated and/or contains fixable mathematical errors. (0pt) Model is not presented or contains significant errors.	Mathematical approach is stated, but aspects of the method(s) are inconsistent, difficult to understand or incomplete.	Provides a readable glimpse into the mathematical method(s) used to solve the problem. The model and solution are novel/creative.	
Clear (WRITING AND ORGANIZATION)	(1pt) The Executive Summary is hard to read and understand (0pts) The Executive Summary is missing or nonsensical.	The Executive Summary is understandable with minimal spelling or grammatical errors.	Correct spelling and grammar is used throughout. Paper is well formatted and enjoyable to read. Visual aids (if appropriate) are well chosen and easy to interpret.	
			Total score (0-12)	

Figure 3: Detailed rubric for M2

Typically, the end-of-term ID exhibitions generate a lot of excitement among students and faculty alike. On average, this exhibition involves 400-500 students spread across 80-90 design teams, 15-20 ID instructors, 4-5 P2 instructors, 7-8 M2 instructors, and 8-9 WTI and TSSC instructors. A total of roughly 40-50 instructors are involved in this grading on exhibition day. Figures 4 to 6 show an example of an ID poster, a M2 poster and a TSSC poster on a single project.



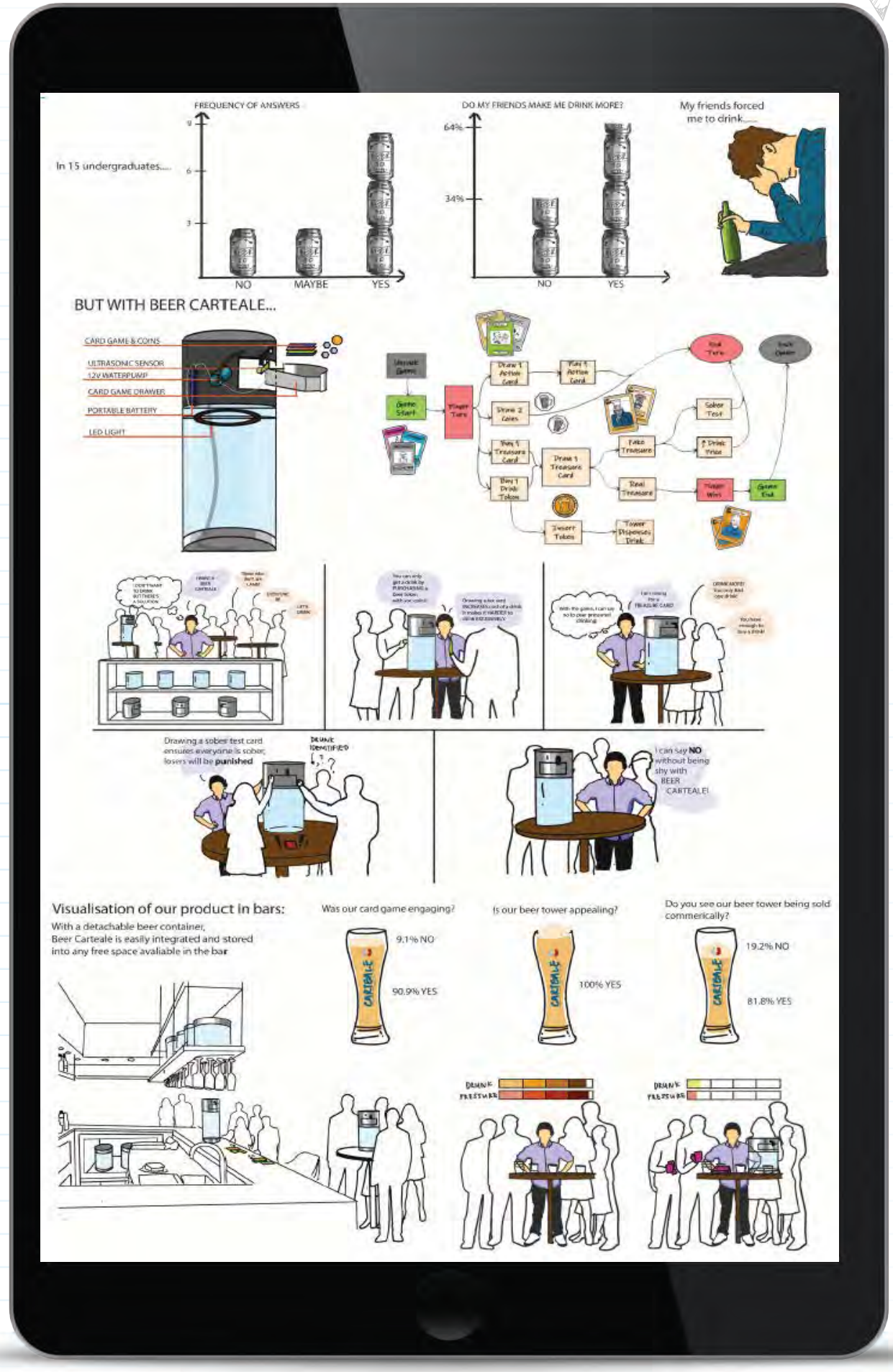


Figure 4: An example of a student team ID poster

MATHEMATICS

DETERMINING WHETHER THE GAME DESIGN SUCCESSFULLY AVOID BINGE DRINKING

Problem Statement :
This report investigates the effectiveness of "Beer Carteale" in preventing binge drinking through determining the maximum amount of alcohol a player can drink in one game according to the choices made by the player in a set number of turns (T).

Independent Variables
Number of turns a player draws BC (C in turns)
Number of turns a player plays an action card (A in turns)

Dependent Variable
Number of drinks a player can afford (D in tokens) from total game currency (BC) gained

Assumptions:

- A player gains an average amount of BC per action card turn (2.33 BC/turn)
- A player suffers a maximum BC loss per turn (1.16 BC/turn) which is assumed to be caused by retaliation which varies more than proportionally with the number of action card turns taken
- The number of drink tokens (D) a player can afford is based on an average token price which is assummed to increase proportionally with respect to the set number of turns (T) (where k = 0.192)
- Number of turns in a game is 15, which is the highest value where token price is less than or equal to treasure card price (5 BC) as we assumed that players will stop buying drink tokens when they cost more than treasure cards.

Proposed solution:
We created an equation that models the total BC a player gains over a game in a set number of turns (T) derived from the number of turns the player draws BC (C) and plays an action card (A) during the game. This equation is subjected to the constraint where the player must choose either C or A in each turn in the game (T = C + A). The total BC value is then divided by the average token price for the number of turns (T) to derive the number of drink tokens the player can afford (D). To find the maximum number of tokens a player can afford (Dmax), we utilised the method of Lagrange multipliers to find the optimal combination of C and A for maximising the value of D.

Equations:

$$\text{Let } f(C,A) \text{ be } D = \frac{1}{0.5(3+(3+0.192\times15))}\left(2C + 2.33A - \frac{1.16A^2}{15}\right)$$

$$\text{Let } g(C,A) \text{ be } C + A - 15 = 0$$

$$\text{For } f_{max}(C, A) \text{ s.t. } g(C, A)$$

Analysis of Model:
Solving the equation, we found that the maximum value of D is 6.84. According to the Institute of Mental Health, binge drinking is defined as having 5 or more drinks on one occasion. Therefore, according to our model the current rules of "Beer Carteale" do not prevent the possibility of binge drinking during a game. However, on observing the number of drinks taken by players in product testing, we found that they on average had about 2 to 3 fewer drinks than our model predicted. We analysed this difference to be due to players choosing to buy treasure cards rather than drink tokens, and the desire for players to hold on to their BC to pay off any action cards used on them in order to safeguard their treasure cards.

Strengths and Weaknesses:
Hence, the weakness of our model lies in its inaccuracy at high values of T due to how players' choice to buy treasure cards directly becomes more prevalent as more turns pass. Also, our model does not account for other choices made by a player such as the desire to hold on to BC instead of immediately spending on drink tokens. The strength of our model lies in its simplicity, allowing one to easily determine D from any combination of C and A at the same time clearly reflecting how the game rules and choices.

Figure 5: The 2D poster for M2 of the student team in Figure 4

Figure 6: The 2D poster for TSSC of the student team in Figure 4\

The overall feedback about the way the 2D project, from informal conversations with students, is mixed. Whereas some students appear unclear about their 2D project goals in the beginning of the semester but are quite happy with the way in which the 2D project is conducted in the overall context of term 2, others feel otherwise throughout the term. Some comments from students include “what exactly do we need to do? And how should we do this in a meaningful way? ”. The general reactions amongst the faculty team members initially mirrored the students’ feelings, but several Iterations of this project in consecutive years have made it a hallmark for term 2 and students have converged towards a better understanding of project‘s deliverables.

APPLYING DESIGN THINKING TO BRING OUT CREATIVITY IN RAFFLES INSTITUTION STUDENTS: A SINGAPORE UNIVERSITY OF TECHNOLOGY AND DESIGN & RAFFLES INSTITUTION COLLABORATION

VANESSA CHIA YUN YAO (UG STUDENT), JUSTIN YAP SIEW MENG (RI), CHAN HOON HOON (RI), PEH LIAN HONG (RI), & DR. FRANKLIN ANARIBA (SMT / EPD)

The Ministry of Education (MOE) Innovation Programme (IvP) is a 9-month long programme for Secondary 2/3 students that aims to develop their creativity and problem-solving skills through utilising the design thinking process to solve real-world problems. The IvP consists of lessons conducted by school-based teacher-mentors, as well as draft sessions with innovation mentors from partner tertiary institutions assigned to each school. During the lessons, students learn skills and strategies necessary for gaining greater understanding of the problem, generating ideas and evaluating solutions, and eventually constructing prototypes of their proposed solutions. On the other hand, draft sessions allow innovation mentors to guide students by sharing knowledge and expertise to stimulate creative thinking, providing advice and feedback on the feasibility of ideas, and proposing changes and improvements to be incorporated into successive prototypes.

Since 2018, Singapore University of Technology and Design (SUTD) lecturer Franklin Anariba has been collaborating as the innovation mentor to Secondary 3 Raffles Institution (RI) students. In 2019, the team of SUTD mentors expanded to include undergraduates Lim Yi Lin, Koh Kai Ting and Vanessa Chia (class of 2022), under SUTD's Undergraduate Research Opportunities Programme. The latter stayed on to mentor RI students in 2020.

Before COVID-19

During the draft sessions, students were introduced to a series of tools/methods, such as diagram drawing (Discover phase), user need analysis and user observation (Define phase), ideation techniques such as C-sketching, sketching/drawing, and digital modelling (Develop phase), and mock-up and prototyping with various materials (Deliver phase).

Communication of ideas from students to mentors was encouraged through sketches and drawings. A series of drawings are shown in Figure 1, wherein it is observed (1) the details of the sketches, (2) completeness, and (3) progression over time.

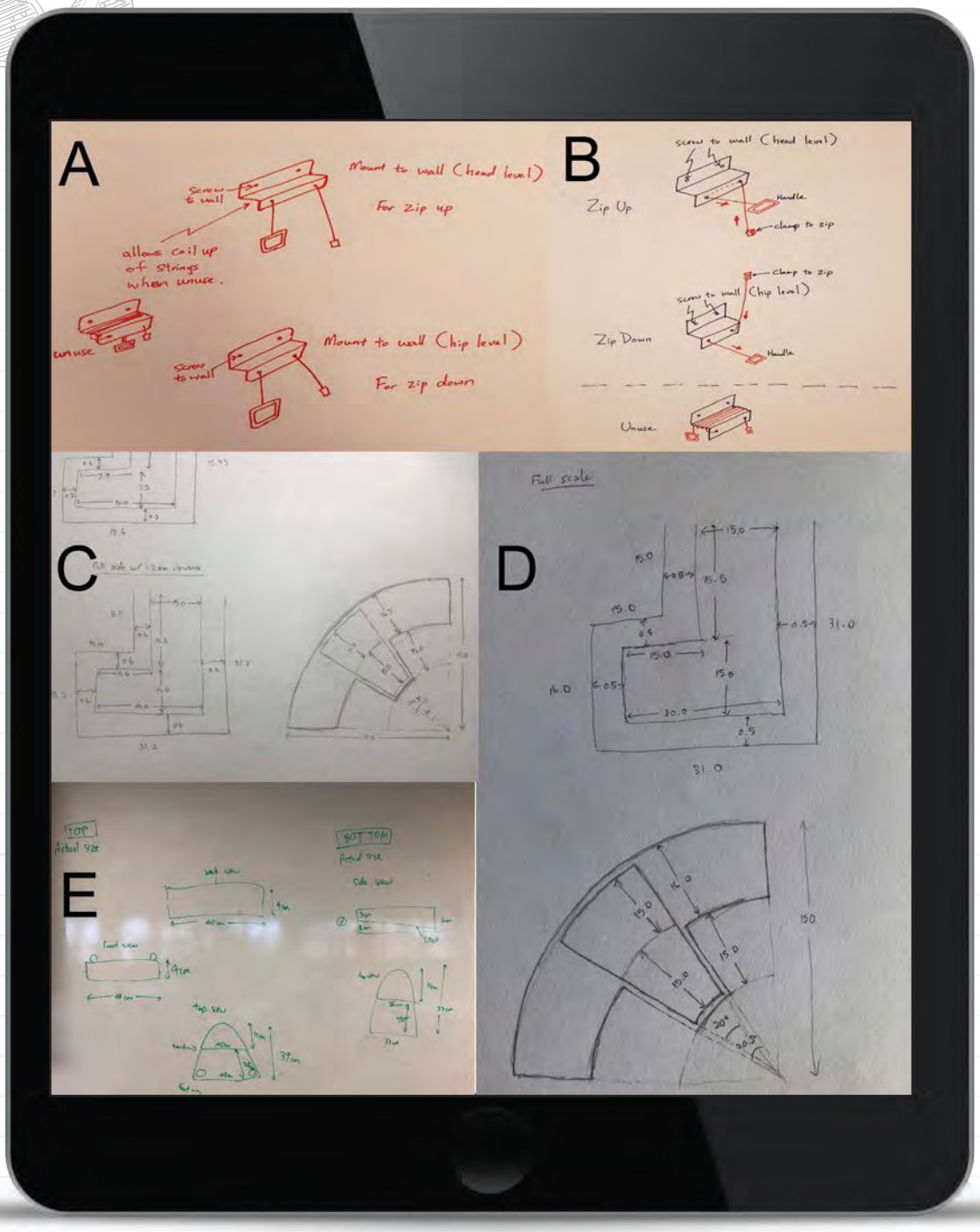


Figure 1: Panels A and B depict annotated sketches of the operation and stowing of a pulley mechanism, while panels C and D illustrate different scales and tolerances for a twist-lock joint. Panel E illustrates a booster seat as seen from different angles

Cardboard prototyping was mandatory to allow both mentors and students to better visualise ideas generated for each student project (Figure 2). Students were encouraged to use paper, cardboard and other inexpensive recycled materials to come up with their first low-fidelity prototype. In addition, several draft sessions were dedicated to prototyping, where materials such as penknives, hot glue, tape and cutting mats were provided by the SUTD mentors. With the guidance of the undergraduate mentors, RI students were also able to come up with refined prototypes, which were fabricated using SUTD FabLab equipment such as 3D printers, which the latter did not have access to (Figure 3).

Figure 2: Cardboard prototyping during a draft session at SUTD

Figure 3: Student prototypes of a 3D printed polylactic acid electric nail clipper holder (panels A and B), and a foldable stool made from wood and aluminium (panel C) fabricated at the SUTD FabLab

During COVID-19

However, the COVID-19 pandemic introduced two challenges to the collaboration in 2020, namely, (1) SUTD mentors could no longer meet in-person with RI students for the draft sessions, and (2) RI students lost access to prototyping facilities through the SUTD mentors. To tackle the first challenge, the strategy of leveraging on video conferencing technologies was employed, and draft sessions were held over Zoom. However, this precipitated the problem of the quality of virtual interactions not being comparable to that of physical ones. To combat this, the number of draft sessions was maximised as far as possible but was ultimately limited to how much students could accomplish within their own free time.

The second challenge meant that conventional forms of prototyping could not be carried out. Therefore, digital prototyping tools, such as TinkerCAD, Blender and Inventor Professional, were utilised for students to communicate their ideas, and to gather feedback on their prototype via mechanical integrity simulations as an alternative to user testing (Figure 4). However, it was noticed that students lacked the relevant skills needed to use these tools, and as such, a just-in-time lesson on Computer Aided Design (CAD) and Finite Element Analysis (FEA) was prepared (Figure 5). Through a survey questionnaire administered to all students at the end of the programme, it was found that students enjoyed the just-in-time lesson, albeit advanced.

Eventually, two out of five student projects mentored by SUTD faculty and undergraduates were invited to showcase their work at the Young Innovators Fair in 2019, a significant achievement considering only five out of a total of 90 groups across all secondary schools nationwide were given the opportunity to do so.

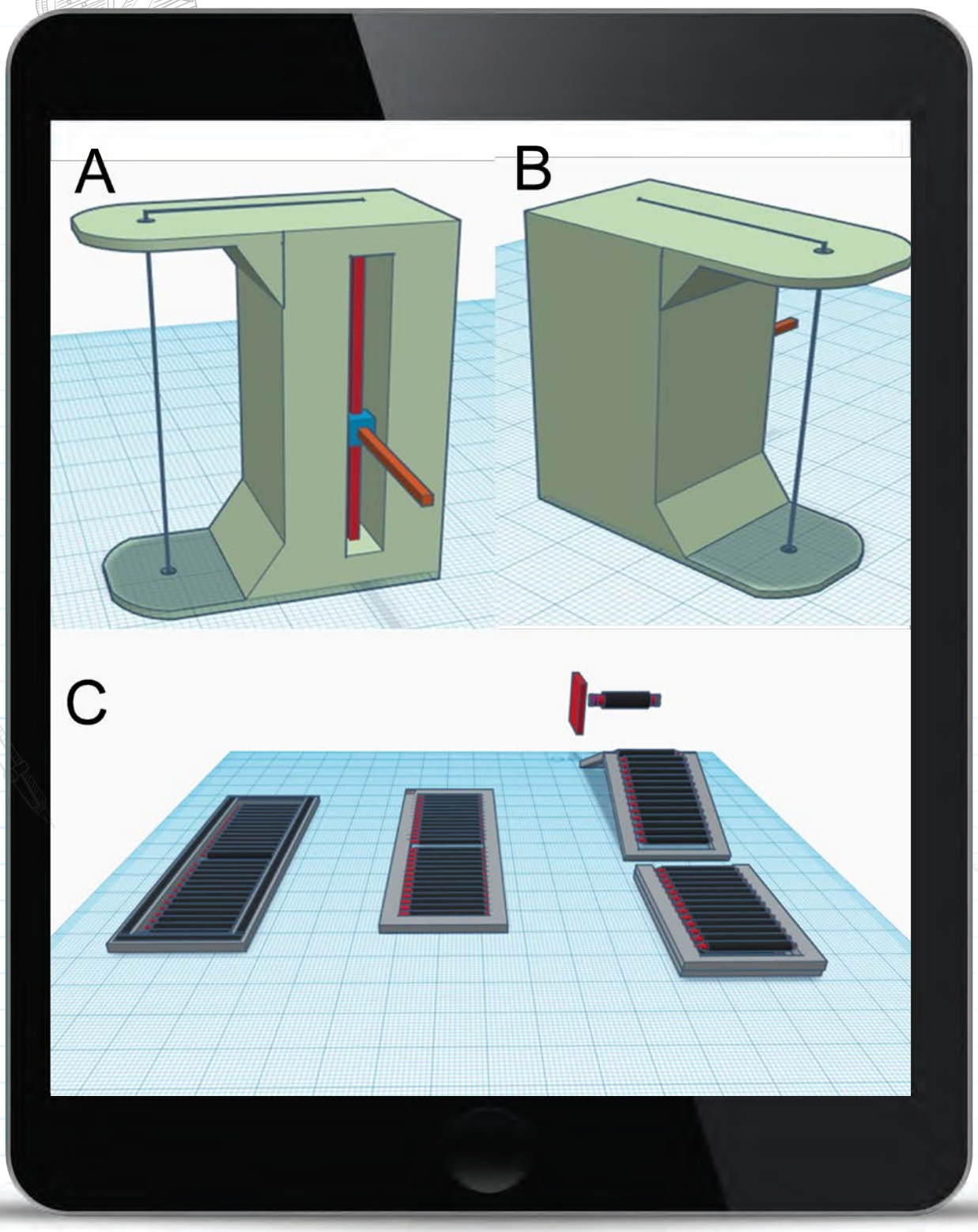


Figure 4: 3D modelling of a contraption for pulling up zippers in hard to reach places (panels A and B), and a wheelchair transfer board (panel C) using Autodesk TinkerCAD

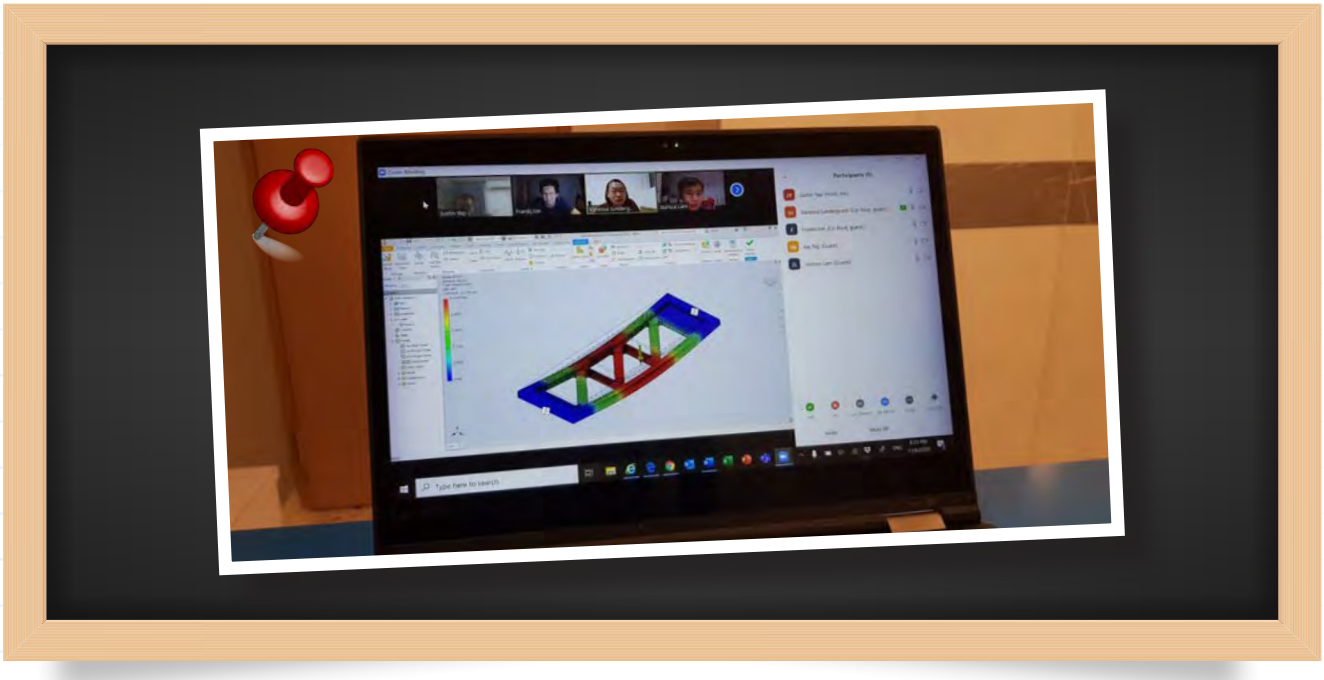


Figure 5: Teaching students how to conduct FEA simulations and interpret the results in Autodesk Inventor Professional

To conclude, the main takeaway from three consecutive years of IvP mentorship was that the success of bringing out innovation in secondary school students through the application of design thinking hinged on the provision of sustained just-in-time feedback, preferably physically. This meant additional draft sessions conducted weekly at SUTD in 2019, and triweekly virtual sessions in 2020, in addition to the three compulsory draft sessions stipulated by MOE.

Just-in-time feedback enabled students to clarify their doubts in a timely manner, which increased student engagement and motivation levels. Furthermore, IvP has also exemplified how just-in-time training catered to each project can sustain student interest and even stretch the abilities of students. Through the introduction of advanced prototyping methods such as 3D printing, CAD and FEA, students can see the relevance of these lessons and apply them in their own projects.

Acknowledgements

The authors would like to express their heartfelt gratitude to Lim Yi Lin and Koh Kai Ting, who played instrumental roles in the development of prototypes for the RI students. The authors would also like to thank the following students for their participation in IvP 2019 and 2020: Ian Ng Khai Ven; Joshua Kyle Lam; Lucas Lee Yiheng; Muhammad Illham Wafiy bin Moham; Ziv Ng; Chia Po Zhe Craven; Fong Yi Jun; Sean Hua; Bryan Koh Cheng Wee; Muhammad Nabil Naqiuddin bin Mohammad Iskandar Naim; Pritam Saha; Danil Chang Wei Yi; Dong Zihan; Euan Koh Zhen Bin; Kow Kai En Elijah; Lee Yu Xuan Ronald; Venkatesan Ubanishathan; Kee Hong Ming Wesley; Wang Qirui; and Yang Xianyan, Winston.

FACILITATING VIRTUAL MENTORSHIP AND SUPERVISION OF A GROUP DESIGN CHARRETTE

DR. DANIEL JOSEPH WHITTAKER (ASD)

The changes that all strata in the world of higher education have had to make, to accommodate new modalities of living and learning, have been acute. Within the realm of continuing the tradition of collaboration among small groups of students, this article focuses upon how technology has been harnessed to ease perceived communication gaps and foster a greater degree of collaboration in the realm of undergraduate architectural education. This brief article will cover how Zoom's video conferencing software's 'share screen' function was utilized to display student computer-generated drawings, in addition to enabling greater communication via digital on-screen 'draw' and 'notation' functionalities. These abilities which exist within the software can enhance a greater degree of cross-student idea-sharing through pre-prepared visual imagery as well as on-the-spot sketching, annotation and text layering; all of which is done to alter, improve and enhance the students' design ideas and graphic-imagery-based proposals.

Four undergraduate Architecture Sustainable Design (ASD) students: Megan Moktar, Grace Teo Yu, Nicholas Lim, and Siao Si, worked together from May through September 2020, to brainstorm, develop design criteria, create and submit a design project for a future multi-use work-live tower to be developed adjacent to Marina Bay Sands complex in Singapore's Central Business District. This submission aims to chronicle not their final product submitted to the jury for evaluation, but instead, demonstrate how technological tools assisted the four students achieve a goal largely without meeting face to face on campus. Utilizing Zoom's virtual meeting tools to meet in smaller pairs and also collectively with myself, the supervisor, the design submission was assembled. This is a major feat when typical design 'charrettes' (fast-paced creative brain-storming competitions) are heavily reliant upon intense analog meeting techniques and tools. Such past methods, as reliable and quotidian as they were, had to be eschewed due to the impact of the Covid-19 pandemic.

In the recent past, having multiple design students sitting together at a drafting table with large sheets of paper and tracing paper laid out in front of them, discussing and marking up drawings, site plans and photographs with pencil, marker and adhesive tape were thought to be essential to a successful design process. The advent of contemporary global-health events immediately changed this methodology. The design process of generating iterations of ideas on top of ideas, or making an 'esquisse,' traditionally utilized the analog tools of pencil, pen, marker, and eraser, sketching upon layers and layers of translucent tracing paper. A beautiful palimpsest would eventually emerge from such creative fervor.

The complete transfer of an architecture student's toolkit to a digital palette could not occur overnight; however, in this instance, it was requisite due to the speed and fervor of change that swept across the planet. The students, adept at accepting new tools to visually and verbally communicate, harnessed Zoom to enable as seamless as possible communication of various design strategies, in a 100% digital format. A mixture of digitally-hand-draw sketches are featured in Figure 1, with annotation, that one presenting student was able to share with the cooperative group.

Figure 1: Digitally-hand-draw sketches on 3 July 2020

Discussion, annotation, varying opinion resolution all took place quickly in the on-line platform; Figure 2 shows multiple parties digitally sketching on top of another students' digital plan, with notes and layers of digital-marker mark-ups. Vociferous parties could push for favored design solutions at this schematic phase of design; others could mark up the digitally shared screen for all to witness.

Figure 2: Multiple parties digitally sketching on top of another students' digital plan, with notes and layers of digital-marker mark-ups by 25 July 2020

Evidence of further progression of the groups' progress is exhibited in the digital model. SketchUp, Revit, Grasshopper and Rhinoceros software were all utilized by various students to create their own preliminary digital models. Resultant discussion revealed variations in interpretation of criteria and personal value systems in which positive attributes of design solutions were judged by. Lively discussion took place on the digital platform along with further digital-marker annotation. A complex sub-level for the river-canal (shown in blue) was under debate in this screen capture (Figure 3).

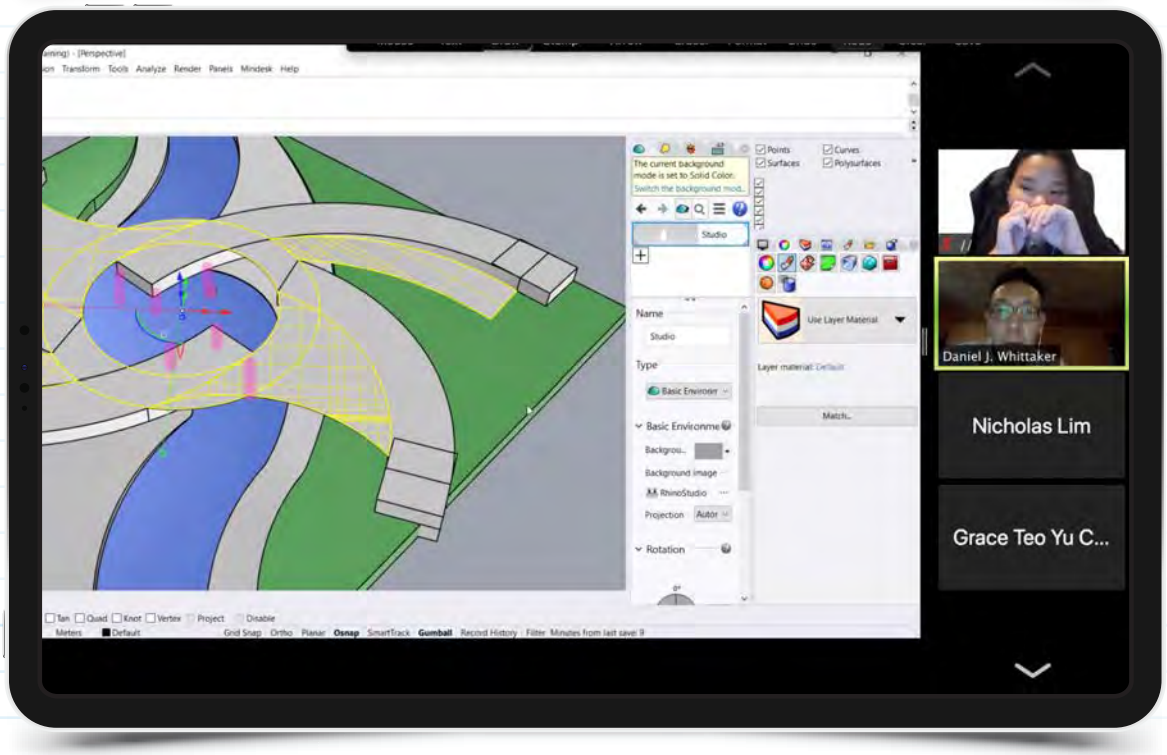


Figure 3: Further annotations as at 31 July 2020

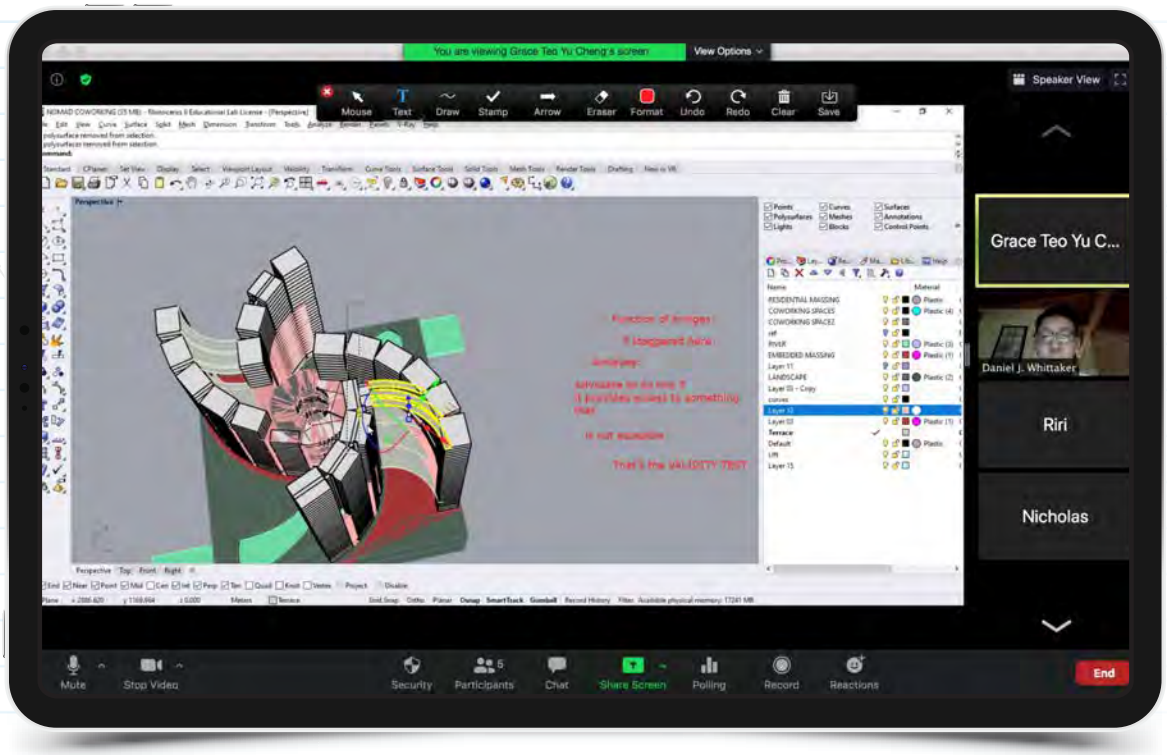


Figure 4: Drawings with three dimensional digital modeling as at 18 August 2020

As evidenced in Figure 5, a geometric growth in the level of resolution has been achieved! Yet the digital platform still allows for each member of the group to give feedback to one another for individual areas of the model were assigned to different team members and as they all cooperated together to conclude the project, each party was able to produce useful feedback and critique about the visual appearance of the semi-final three-dimensional computer generated perspectival renderings. A success at hand in digital team-collaboration in a fully digitized environment; eschewing what typically and traditionally was a fully analog campus-studio-based environment.

Figure 5: Final visualization as at 3 September 2020

Overall, the agile students were adept at embracing the new technology and pushed it to its outer capabilities to allow them full creative debate, expression and ultimately, problem solving and design resolution. Nevertheless, it is good to consider the advantages of both the traditional and digital implementations (Table 1).

TRADITIONAL ON-CAMPUS CHARRETTE

Aspects	Advantages	Disadvantages
Group work	Group meetings in studio space	• Finding quiet space to meet to not disturb others • Waiting for late group members to show up • Digital images need to be printed out to draw on top of
Communication	Easy for others to talk/ know when to talk	Frequency of meetings can lead to group fatigue
Resources	Hand-drawn overlays are tangible	• Finite amount of tracing paper available • Hesitancy to draw on top of another image or work
Drawing skills	Deft layering of colors, sketches by hand	Limited palette of markers, pencils, drawing tools

DIGITAL CHARRETTE

Aspects	Advantages	Disadvantages
Group work	• Each person in their own space • Most on-time since no transit issues	100% dependent on WiFi availability
Communication	No need to print out onto paper Digital space knows no boundaries	Frequency of meetings fairly effortless
Resources	Less reluctance to draw on a digital image	• Finite amount of tracing paper available • Hesitancy to draw on top of another image or work
Drawing skills	• Digital imagery is ephemeral to some extent • Unlimited color palette and digital tools	Soft touch of hand drawing lost

PEDAGOGICAL SUPPORT

SUTD LIBRARY: A PARTNER IN YOUR LEARNING JOURNEY

The SUTD Library offers a wide range of training sessions for different target audiences in the SUTD community.

Due to the COVID-19 pandemic, most of our training sessions were conducted online via Zoom, Microsoft Teams or webinar style. To allow asynchronous access by students, some of the sessions were recorded and made available via e-Dimensions (the learning management system). Only a few on-demand on-site sessions were conducted during lesson time. Practical hands-on activities were incorporated into the training sessions to help attendees understand the topic better.

To support self-directed learning, SUTD Library curated online quizzes on Plagiarism where students can conveniently access them via our Library website.

By adopting a strategy of collaborating with various departments/offices to offer targeted and customised training, the SUTD Library was able to better reach different target user groups and support their learning needs (See Diagram 1). For example, first year students were provided training on 'Plagiarism', 'Citation & Referencing Skills', 'EndNote Tools', etc. Whereas more senior students were provided training on 'ACEing Capstone Projects', 'How to conduct better research', etc. To better prepare them for the workforce, Library tied up with the career centre to offer 'Tools & resources for Presentation, Communication, Technical Writing, etc'.

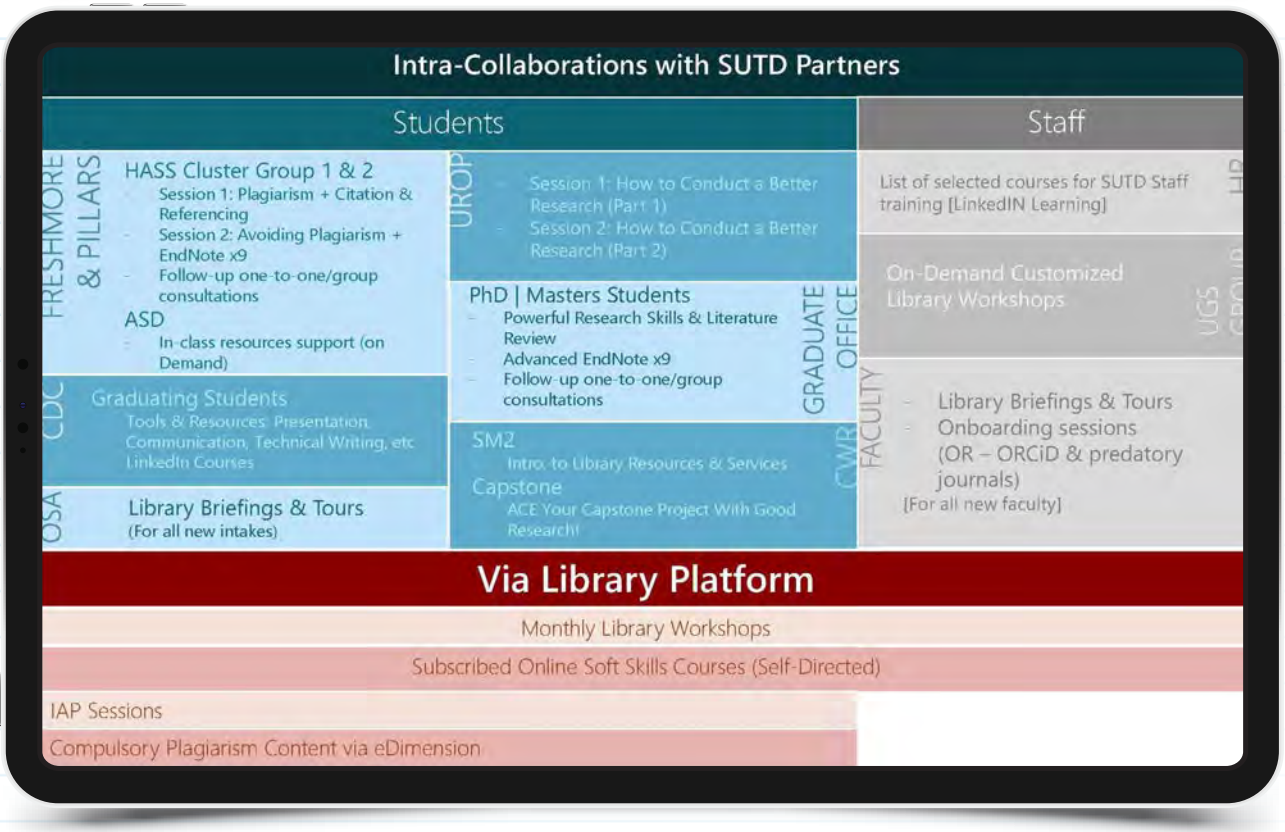


Diagram 1: Overview of collaboration and trainings offered for SUTD Community

Monthly Library eWorkshop Series

In addition to the targeted training sessions for specific user groups, SUTD Library also organises a monthly series of eWorkshops on various topics such as 'Benchmarking Your Research Performance', 'Introduction to Information Searching Skills', 'Enhancing your Online CV by Exploiting LinkedIn Learning Resources', etc (See Diagram 2).

These eWorkshops are open for anyone in SUTD to join. Participants are given the flexibility to choose the preferred day they are available to attend the training.

Our FY21 eWorkshop Series is available for registration @ our Library Website.
https://mylibrary.sutd.edu.sg/explore-possibilities/2021-sutd-library-eworkshop-series

Diagram 2: Monthly Sessions Opened for Registration for SUTD Community

Library Training Menu

We designed a training menu for our Undergraduate and Postgraduate students where faculty have the option to select the training topics that are suitable for their classes. The training menu lists the various training topics that are catered to the various levels of students starting from the day they join SUTD. The trainings equip students with both research and information literacy skills during their learning journey in SUTD.

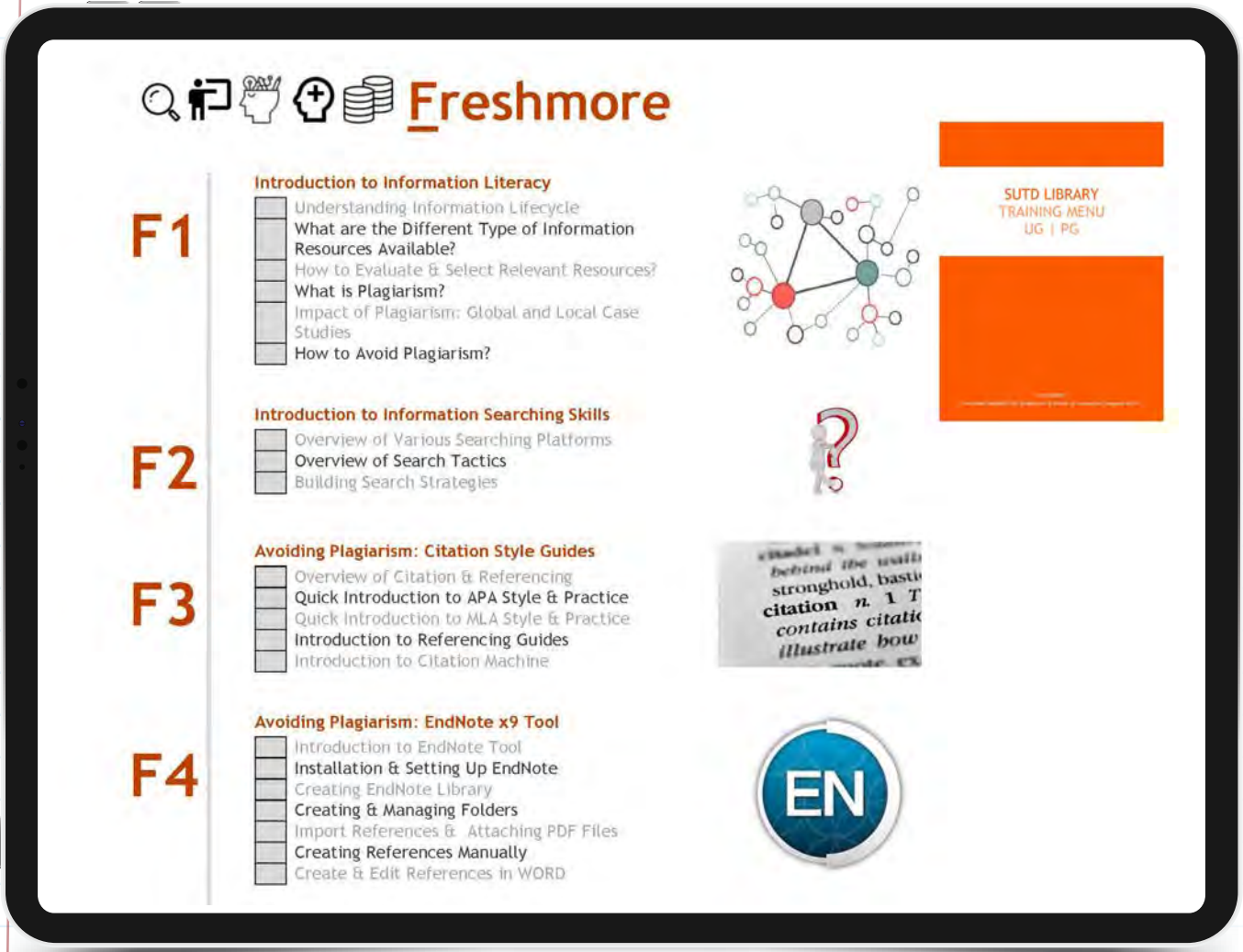


Diagram 3: Sample Extract from Training Menu

This training menu is circulated to the various pillars/clusters faculties for their selection.

To request for customised training sessions, please drop an email to:
Vijaya_lakshimi@sutd.edu.sg and copy library@sutd.edu.sg

Self-Directed Learning - Online Soft Skills via LinkedIn Learning Platform

Soft skills training is key and important in grooming our students to be workplace ready. SUTD Library specially curated sets of recommended online learning skills/ personal development courses such as leadership, presentation, project management, etc. that are available for students' access via the LinkedIn Learning platform. Courses from our library subscribed contents from LinkedIn Learning and IEEE courses can be found in these sets of courses.

These courses are available 24/7 via our Library website (https://mylibrary.sutd.edu.sg/soft_skills_courses_linkedin_learning) where students have the flexibility to take on the courses any time and at their own pace.

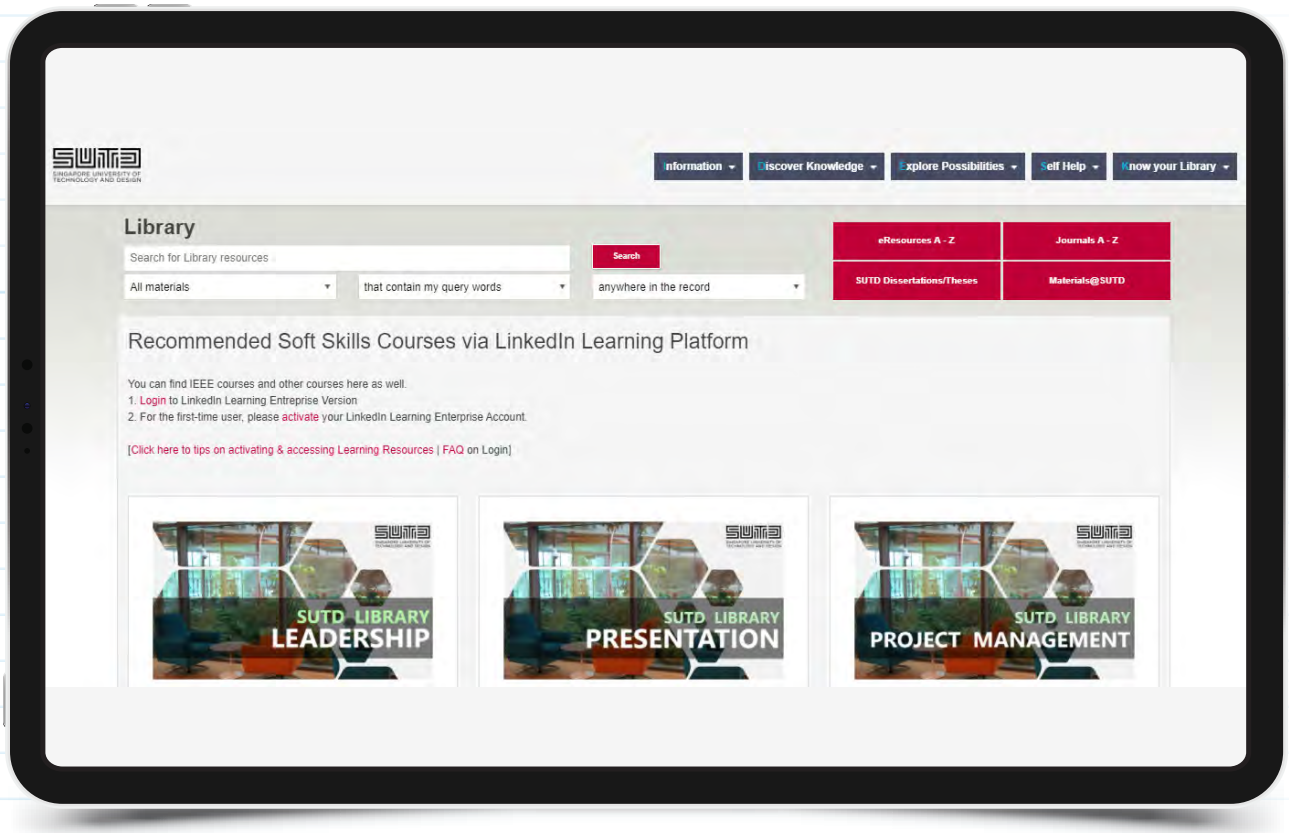


Diagram 4: Sample Extract from Library Website

For any queries, please contact library@sutd.edu.sg.

ABOUT LEARNING SCIENCES LAB

Learning Sciences Lab at SUTD was established on 15 July 2016. As part of the Office of Undergraduate Studies, it aims to support faculty and learners in engaged teaching and learning. Learning Sciences Lab is directed by Dr. Nachamma Sockalingam, under the guidance of Associate Provost for Undergraduate Studies, Professor Pey Kin Leong. LSL team consists of Mr. Clement Lim.

LSL SERVICES

- Introductory Teaching Course
- Pedagogical Workshops/ Seminars/ Talks
- SUTD-AHE Educational Fellowship Programme
- Scholarship of Teaching and Learning (SOTL)
- SUTD SOTL Circle
- Asian SOTL Circle
- Pedagogical Research: Consultation & Collaboration
- Teaching and Learning: Consultation & Collaboration
- Pedagogy Day
- Pedagogy Newsletter/ UGS Newsletter
- Online Resources and Communications
- Grant Proposal Review

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